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**ARCHAEOLOGICAL SENSITIVITY MODEL:
a Cultural Resource Management Exercise**

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Survived to weave this fictive spell;
And, gentle reader, you as well,
The fountainhead of all remittance.
Buy me before good sense insists
You'll strain your purse and sprain your wrists.

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ABSTRACT

The coastline of South Africa is used by diverse groups of people for a wide variety of reasons ranging from economic, scientific, social, and recreational. For the users to obtain optimum utility it is imperative that ways and means of developing the coast and its potential are put in place, in the face of rapid urban, industrial, and rural development. In the past the coast was an important place for human settlement, as it still is today. Past human settlement left traces that are now threatened by development. The fragile nature of these past settlements means that there is an urgent need to preserve these archaeological sites.

Archaeologists and other conservationists recognise that development is a fact of life. Therefore in order to realise fully the potential of the coast a proper management plan for archaeological resources is needed. The management plan should be drafted with input from natural and social scientists, economists, technical experts, and communities that depend on the coastline for their livelihood. This will ensure that development is well planned, user conflicts resolved, and ecological damage minimised. The management plan for coastal archaeological resources will take into consideration the sensitiveness of the area and the potential for development. This project will be undertaken in consultation with professional archaeologists, the Department of Environmental Affairs, the National Monuments Council, biologists, geologists, local communities, town planners, architects, and other stakeholders.

The objective here is to formulate a "red flagging" system that will alert the appropriate regulatory institution and therefore enable the institution to encourage development where it will do least harm to archaeological resources. The broad aim above is addressed by first documenting existing information on archaeological resources and current patterns of distribution which are then entered as overlays in a Geographical Information System model. The distribution maps of archaeological resources together with geological, geomorphological and vegetational GIS overlays are used to predict site distribution in unsearched areas in order to produce an Archaeological Sensitivity Model.

The Archaeological Sensitivity Model will result in the establishment of synergies between conservation, heritage management and research by linking Cultural Resource Management with coastal management. This process will lead to the rationalisation of knowledge management with greater co-operation and agreements with research organisations, universities, business and other institutions.

Chapter 1 outlines the problems facing heritage management in general, but with a specific emphasis on coastal archaeological sites. In Chapter 2 the management tool, Geographical Information Systems (GIS) is introduced. A brief background on the application of GIS in archaeological research, and methodological and theoretical issues are discussed. Chapter 3 introduces the concept of predictive modelling.

Chapters 4, 5 and 6 outlines the infrastructural, environmental and archaeological data about the study area. This is necessary to provide a framework for assessing the distribution of archaeological resources for management purposes. In Chapter 7 the concepts of density, diversity and rarity are introduced.

In Chapter 8 statistical inferences on the archaeological data together with the environmental data in order to develop the Archaeological Sensitivity Model. In Chapter 9 the Archaeological Sensitivity Model together with the concepts from life sciences – density, diversity and rarity is used to devise a management plan for archaeological resources. The concept of ‘archaeological reserves’ is introduced. In the last chapter, Chapter 10, the concept of integrated management approach in the conservation of archaeological resources is outlined.

CHAPTER 1. INTRODUCTION

The 'coast' as used here is the land/sea interface, which comprises the immediate coastline, coastal plains, wetlands, estuaries, and river mouths. The coast is defined as the land that is affected by being near to the sea and the sea that is affected by being near to the land, the spatial area that gets its character mainly from the direct interaction between land and sea. The boundaries of what constitute the 'coast' are loosely defined and tend to vary because of national coastal policies that often provide the guidelines for defining coastal boundaries, depending on management objectives (DEA&T 1998). The coast is dynamic, attracts people for a variety of reasons and is heavily impacted by pollution and conflicting land-use. The coast also acts as a natural defence against storms, floods, and other natural disasters. Furthermore the coast is subject to different property regimes, which means that the control of access to its resources is an issue and users may subtract from the welfare of others. The question of access is not clear: who will have access, who will be excluded, how will benefits be shared, and who has jurisdiction.

The Resource

The coastline of South Africa is used by diverse groups of people for a wide variety of reasons ranging from the economic to the social and the recreational. For the users to obtain optimum utility it is imperative that ways and means of developing the coast and its potential are put in place, in the face of rapid urban, industrial, and rural development. Because South Africa is a maritime nation with a long coastline, the coastline is a national heritage that needs to be guarded against senseless plundering and degradation. In both prehistoric and historical times the coast has formed the basis of livelihood of the people of South Africa, and in the present and the future vast sums of wealth are and will be generated from the coast.

Past human settlement left traces that are now threatened by development. The fragile and non-renewable nature of past settlements means there is an urgent need to preserve these archaeological sites. The National Monuments Act (Act No 28 of 1969) requires that a permit be obtained to excavate any archaeological and palaeontological sites and deposits. Furthermore, the Environment Conservation Act (Act No 73 of 1989) and the 1994 Regulations recommend an assessment of the impact of a development on the cultural and historic environment of a site. These acts and the DEA&T guidelines for Integrated Environmental Management (IEM) procedure means that developers often request information on possible cultural resources of an area prior to development. More often than not the information is either not available or is in a format that is not suitable for public presentation. Furthermore many archaeologists are very reluctant to give away information because of a lack of guidelines as to how the information can be used, what it means. As a result archaeologists are sometimes viewed as being against development (Coetzee & Kaplan 1994).

The Threat

World-wide the demographic trend in coastal areas is towards increasing population concentrations, which is further exacerbated by the general increase in population growth. It is estimated that the world population will reach 8.5 billion by 2025 and that most of the increase will take place in less developed countries. Most of these countries put heavy reliance on their coastal zones to provide food and homes. Furthermore, most of the demographic growth will occur in an urban setting and be concentrated in the coastal zone which tends to have higher consumption levels than their rural counterparts as well a different consumption patterns (Burbridge 1993).

Demand for property adjacent to estuaries, lagoons and sheltered bays is especially high, because of the aesthetic qualities and diversity of recreational opportunities afforded by these sheltered and productive systems. It is estimated that the population of the world's coastal zones represent between 50 percent and 70 percent of the world

population (Burbridge 1993). It is these environmentally sensitive areas that are most vulnerable to ad hoc, uncoordinated planning and development. Potential climate changes, and in particular sea-level rise, may further exacerbate management problems. Added to this, water abstraction from rivers and wetland areas increases the management problems for sensitive low-lying coastal and estuarine systems.

The coastal zones of the world are of great economic and environmental importance to individual countries and to the world community. Mining, oil and gas development onshore and in shallow waters in coastal regions account for a sizeable amount of nations Gross Domestic Product and employ a significant proportion of the population. In addition, in most coastal nations there are increasing demands for coastal sites for tourism development (Burbridge 1993). Fisheries provide foreign exchange earnings and represent a significant source of protein, and employment to many coastal communities. For example, world-wide 95 percent of all marine capture fisheries are derived from coastal waters, with the rest coming from deep marine waters (FAO 1992). Last but not least, the demand for new port and harbour facilities to service increasing international trade is adding to the competition for coastal land.

World-wide, most coastal countries have recognised the environmental, social, cultural, spiritual, economic and educational value of their coastal areas. Many have formulated integrated policies and developed co-ordinated management programmes to promote the sustainable use and development of these resource-rich areas. The overall goal of these programmes is to promote the conservation and sustainable, multiple use of coastal resources and areas. Various sub-goals and more specific objectives may be defined depending on the issues motivating the formulation of the programme, its focus, the political context and institutional arrangements within which the programme evolved.

The Western Cape's coastal zone, as in many other coastal countries, is under severe and increasing development pressure. Economic development activities including clearing land for agriculture, commercial and industrial undertakings, provision of infrastructural services, and in particular, increased residential and recreational developments, are transforming, and in places irreversibly degrading, the coastal

environment. Much of the coastal degradation, which occurred in the past, can be associated with the activities of the more affluent sectors of the South African society. The absence of legislative provisions and administrative procedures which require that the environmental and social costs of development proposals be evaluated prior to decision-making, are probably the key causes for the inappropriate allocation and development of coastal resources and areas. More recently, factors such as high population growth rates and depressed economic conditions (Ramphele 1991) are resulting in exploitative and environmentally inappropriate approaches to resource use and development.

At present, the political changes occurring in South Africa are having far-reaching implications for coastal resource and area management. Necessary actions to redress the imbalances of Apartheid include the provision of basic needs, the restoration of historic land rights as well as the removal of restrictive legislation. These measures are placing enormous strain on coastal systems and existing facilities. Apartheid policies have meant that access to coastal activities has not kept pace with population requirements. The result is that the provision and expansion of coastal facilities is now urgently required.

The major threat facing the archaeology of the Cape West coast is the removal of surface sediments due to human impact. The utilisation of the Cape West coast can be divided into two components, first that of human population pressure south of the Olifants River and secondly mining influence north of the Olifants River. The coastline south of the Olifants River is favoured for settlement because of its sandy beaches, access to beaches, excellent fishing, good camping sites, and its proximity to Cape Town. North of the Olifants River because of aridity population density drops and the coast is more suitable for mining. The soil is stripped, exposing the old rocky sea-bed. Another prevalent threat to the coast involves the removal of seaweed or kelp, *Ecklonia maxima*, which is then exported to countries such as Japan to be used in the manufacturing process for fertiliser. This is unfortunate because the seaweed contributes towards the nutrient and organic content of sand, and inhibits sand erosion (Boucher & le Roux 1993).

Socio-economic and socio-demographic trends necessitate the establishment of a management plan for coastal resources. Each year there is a dramatic increase in human population, hence further onslaught on coastal resources and most of the increase involve the poor and the young. The resultant effect of population increase is the increase in the rate of urbanisation. This leads to increased pressure on coastal resources when urbanisation takes place in coastal areas. Socio-economically, close to 7 million people live in informal settlements which have inadequate sanitation and basic services. These factors mean that the coastal environment is under constant pressure and without a proper management plan and policies it is in danger of irreversible damage (DEA&T 1998).

Despite these apparent misuses of the coastline, there are conserved areas, which enjoy different levels of protection. There is the West Coast National Park and the Rocher Pan Nature Reserve, and a number of private reserve and local protected areas. But only the West Coast National Park and the Rocher Pan Nature Reserve enjoy any guarantee of permanence. In addition to the already protected locales there is a proposed National Park on the Namaqualand part of the west coast which will extend from the Spoeg River southwards to the Groen River. This proposed National Park would greatly enhance the protection of additional coastal archaeological sites.

Reality

Archaeologists and other conservationists recognise that development is a fact of life. Accelerated economic growth and development are imperative, but they result in further onslaught on various facets of cultural resources. There is a need therefore for a strong, culturally compatible growth and to reconcile the two requires strict management guidelines. This means relying on something else other than the traditional techniques of legislation and policing. A need therefore, for alternative management techniques.

Why is there a need for alternative management techniques if we have the ability to improve traditional approaches - those of legislation and policing? With the success of free markets, this approach has gained impetus as a supplement to traditional approaches, which are command-driven. Is the new approach relevant to South Africa? What is the future view on sustainable development? South Africa does not have much choice since we have rejoined the world community (DEA&T 1993). Our trading partners tend not to look kindly to countries with little regard for their natural and cultural resources when pursuing economic growth. This means that sustainable development is the way forward.

Current environmental consciousness is mainly to the realisation that exponential economic growth cannot continue forever without a catastrophic event because resources are finite and would eventually be exhausted. This is not a way to advocate zero economic growth, hence the need to try and develop contrasting arguments. For example imagine these two scenarios: Increase in consumption of world resources will lead to the increased in scarcity of the resources. In turn the increase in scarcity will result in increase in prices which will trigger a search for alternative resources. What this means is that there are automatic mechanisms within the market to postpone the impending doom. The alternative scenario assumes a world with zero economic growth. Zero economic growth will result in increased environmental damage, hence a world that is both economically and environmentally degraded (DEA&T 1993). The issue is therefore how to grow, not whether to grow.

How does one reconcile economic growth with the protection of cultural resources that appear to be in the way of development? By realising that the aim of any economic policy must be sustainable development. Sustainable development that meet the need of the present society without compromising the ability of future generations to meet their own needs. Sustainable development that ensure the protection of our cultural heritage for the benefit of all the people of South Africa. Sustainable development that will empower local communities to manage and co-ordinate their cultural heritage.

Way Forward

Therefore in order to fully realise the potential of the coast a proper Management Plan is needed. The Management Plan should be drafted with input from natural and social scientists, economists, technical experts, and communities that depend on the coastline for their livelihood. This will ensure that development is well planned, user conflicts resolved, and ecological damage minimised. Furthermore devising and implementing a proper management plan might be cheaper to apply than legislation and achieve the same results, flexible to industry, and allow chosen objectives to be met with minimum costs (DEA&T 1993).

The South African Network for Coastal and Oceanic Research (SANCOR) is developing a GIS-based coastal and maritime research programme, Coastal Action Group (COAST). The broad aim of the programme is to promote the wise use of marine and coastal resources through appropriate marine science, engineering and technology, and specific to the *coast as a resource* the aim is :

“... to provide the scientific support needed for the optimal sustainable development and wise management of the coast and its resources. It aims to identify opportunities for better use of coastal resources and study ways to minimise or ameliorate adverse impacts ...”

In an effort not to duplicate what has been done archaeologist can simply peg their Management Plan to that of biologists, geologists, and other environmental workers. What is not clear is the relevance of concepts from life sciences like biodiversity, uniqueness, pristine versus disturbed regions, minimum viable size of conservation areas and redundancy of objectives, in the conservation of archaeological resources. The key difference is the fact that archaeological resources are neither *ecological systems* nor *natural*; for example, relations between sites do not correspond with relations between organisms. Therefore, there is perhaps a need for the development of new concepts and a regional approach specific to archaeology. Another important difference is that most archaeological resources are buried. As a result, archaeo-

conservation needs to be able to cope with the unforeseen uncovering of vital information where it was not anticipated. There is thus, a need for a pro-active as well as a re-active conservation strategy.

Hence the need to develop a management plan in a comprehensive and interactive process that has a firm legal and institutional framework, so as to maximise benefits afforded by the coast and minimise degradation. According to Agenda 21 of Chapter 17 in the Rio Conference simplicity and integration of the physical world are two important institutional aspects of a management plan. There is a need for more efficiency because of the increasing deterioration on coastal resources, importance of coastal areas in development. Furthermore traditional planning has failed because it tends to ignore connections between objectives, and the critical role of the ocean in the variability of the planet. For example the current increase in global warming leads a to rise in sea level which in turn increases the damage to the coastal zone (UNCED 1992).

Integration of the biophysical world in the conservation of cultural resources is not always possible because but we have imposed an intellectual restriction to how things are and should be done. The current trend is on systems thinking, think more of process than products. What about the conservation of resources which are not systems, for example cultural resources? How can the conservation of archaeological resources be accommodated in the current intellectual climate? One way will be to show that the local communities have a stake in the resources, how the knowledge of about the past will empower them. To maintain momentum of integration, involve all stakeholders and they must perceive benefits from involvement. And the inclusion of coastal development plans with the national development plans, for example the Reconstruction and Development Programme. The institutional framework of such a management plan must take into account these three broad factors, that of Legislation, Infrastructure, and Information (Deacon 1996). Of which the first two are currently being look into at both the national and regional/provincial level.

Legislation must protect archaeological sites and make impact assessments mandatory. For legislation to be effective there must be appropriate and sufficient

information upon which to base legislation. The process of legislation must lead to clear and understandable laws. Last but not least, the laws must be robust and enforceable (Odendaal 1994). Currently heritage management is legislated by the National Monuments Acts (Act No. 28 of 1969, as amended). The law insists that a permit is required by anyone wishing to destroy, damage, alter, excavate, remove from its original site or export any archaeological site or object, including rock paintings or engravings, the contents of middens and cave or rock shelters, or any site occupied by people living in the country before colonisation by Europeans in 1652, and all structures older than 50 years old. With the exception of shell middens and rock-shelters, mining, agricultural and engineering activities are exempted. There are two other pieces of legislation that offer some protection for heritage resources. They are the Environments Conservation Act (Act No. 73 of 1989) and the Minerals Act (Act No. 50 of 1991). These are not ideal either because although the environmental impact assessments (EIAs) are recommended by the Environments Conservation Act (Act No. 73 of 1989), they are not mandatory. The Minerals Act (Act No. 50 of 1991) requires all new mining projects to conduct environmental management programme and that they should include a report on all cultural resources affected by the proposed mining and plans for their protection. Currently new legislation is being drafted as part of the social change that is taking place in South Africa. Plans are for a new law that will insist on mandatory impact assessments of cultural resources.

In the last couple of years South Africa has been undergoing a process of social change, and as part of the change there is re-prioritisation of government resources. Heritage management is competing with other social concerns for funding. As part of the new legislation, environmental and heritage management will likely be devolved to the provincial governments, although there will still be some form of national policy and legislation. There is a need to develop infrastructure that will provide staff and funding to ensure that impact assessments and mitigation are done. Furthermore infrastructure needs to be in place so that any form of development is monitored. The infrastructure can be in the form of Regional Services Councils (RSC) or Local Councils who will be equipped to deal with cultural resources in their areas (Deacon 1996).

Inventories are the primary information resource for heritage management and planning (CIDOC 1995), because they help avoid crisis management by providing an early warning system for planners and developers. They provide information enabling archaeological heritage management to benefit collectively from past fieldwork (Deacon 1996). At the present moment in South Africa there is a lack of detailed and reliable information on site locations. Even in cases when information is available the organisation or the format in which it is available is haphazard and inconsistent. This failing is made more by the reluctance of archaeologists to make site distribution maps public. In cases where reliable archaeological inventories are in place there are often problems. Some inventories are not accessible electronically, some have information that need to be interpreted by an archaeologist who has intimate knowledge of its limitation, some were developed for research purposes and thus, have little value to a developer because only specific sites were recorded, some inventories tell us more about where archaeologists have lived and worked rather than the distribution of the people they are studying. Last but not least there is a problem as to who has ownership of the information gathered for research. Do archaeologists make information on archaeological sites available only to other specialists? Or can they make the information available to all interested people, public, developers, and tourist guides?

The challenge facing heritage management is to have inventories that are accessible enough to provide maps of site locations, allow relative significance of sites to be assessed, have a facility to analyse information so that predictive models can be generated for areas that have not been surveyed, and be maintained with minimum cost in effort and finance (Deacon 1996). Existing inventories include the Archaeological Data Recording Centre at the South African Museum (Deacon 1996). The Archaeological Data Recording Centre was established in the 1960s, but the system was not kept up to date such that its integrity suffered in the 1980s. As a result a decision was made to establish regional data recording centres in all Provinces. Furthermore there are also specialist databases like rock art, historical shipwrecks, Iron Age sites, and the Later Stone Age sites in the south-western Cape being maintained by various institutions around the country. The Spatial Archaeology

Research Unit of the University of Cape Town has over the years been conducting archaeological surveys on the Cape West Coast. This valuable record contain results of more than 20 years of work done in order to understand the past better.

According to a questionnaire that was circulated in 1995 these were the main aspects of archaeological data management that respondents thought need most urgent attention (Deacon 1996):

- Computerisation of the accession register or card index.
- Data capture.
- Linking up with a GIS mapping system.
- Using the database to identify new research projects.
- Checking database entries for accuracy.
- More sophisticated or user-friendly software.
- Auditing artefact collections to check what should be there is in the store.
- Making data available to other institution via the Internet.
- Intensive field surveys to broaden the database.
- Making data accessible to paying clients.
- Upgrading computer capacity.

The rationale behind setting up archaeological site inventories for planning purposes is based on the premise that we can apply the experience we have gained in the past to predict where sites may occur in areas that have not been surveyed, to assess the

relative significance of sites and projects and to plan for site protection and management. (Deacon 1996)

The broad aim above - establishing a 'complete' site inventory - will firstly be addressed by documenting existing information on archaeological resources and current patterns of distribution which will be entered as overlays in a GIS model. Then spatial distribution of archaeological sites will be manipulated statistically together with chosen environmental variables in order to create an Archaeological Sensitivity Model. The Archaeological Sensitivity Model is a map outlining the known current patterns of distribution of sites. The map will also indicate the relative likelihood of finding an archaeological site in different regions of the study area.

A number of key decisions were necessary in order to fulfil this objective. Firstly we had to decide on an appropriate study area. A 20 kilometre strip on the West Coast starting from Milnerton to the Orange River was chosen as the study area (see Map 1 in Appendix C). The decision was based on the existing knowledge of where coastal sites are located - coastal site being determined by the presence of marine shell and other marine organisms. Furthermore this area is currently the focus of development from the mining, industrial, housing, and recreation sector of the economy. This decision was also more or less dictated upon us by the research interest of Spatial Archaeology Research Unit and the Archaeology Contracts Office, which is the Cape West Coast. The nature of the project is such that future additions to the study area are possible if a need should arise. In addition to the above reasons there is high visibility of archaeological data that is in danger of permanent damage due to rapid development taking place in the coast.

The second decision was on site categories, and these are consistent with those used most commonly by archaeologists in South Africa. These are based on age and technology of the artefacts found in the site. They are the Earlier Stone Age - ESA, Middle Stone Age - MSA, and Later Stone Age - LSA. There are two main reasons for separating sites into categories. Firstly, it makes sense for Cultural Resource Management purposes because the conservation of an LSA Rock Art site involves a different strategy than an open Middle Stone Age site. Secondly, a composite model

made up of distinct models for each site category will result in a greater resolution, and also more useful from a Cultural Resource Management perspective. Dividing site data into temporal types also has an impact on the notions of diversity, uniqueness, and sustainability, which need to be considered when drafting a management plan. It does not make sense to find out that of the thousand sites that are protected, 99 percent of them are 'similar' Later Stone Age sites. Notions of diversity, uniqueness, and sustainability implies that archaeologists have to fully understand the relationship between the resource and its exploitation, hence the existence of a proper and accurate audit.

Historical sites in the study area have been excluded for a number of reasons. The implications of the term historical sites is such that I would have to included structures as recent as the 1930s . Nevertheless leaving historical sites is not consistent with the fulfilment of the objectives of this project - designing an information framework for management of cultural resources -, but if in the future a need arise for the inclusion of historical sites, the scope is there. The inventory of archaeological sites will be designed in a manner that will allow the addition of new information when it becomes available. Future researchers will be able to include additional archaeological sites, new attributes to known sites, and other additional information at no extra costs other than improving the computer resources

In the past environmental circumstances were critical in influencing where people chose to live. That constraint has been only marginally reduced with the advent of technology. By choosing the 'right' environmental variables therefore it should be possible to predict the location of sites from a relatively small sample of known sites. The choice of environmental variables was made intuitively. Presently seven primary variables have been noted for inclusion in the formation of the model. These are Topography, Geology, Rainfall, Hydrology, and Vegetation. From these six variables a number of other variables, termed secondary variables can be derived. For example, from the Digital Terrain Model it is possible to get two variables indicating slope, and aspect.

In addition to the above outlined environmental variables, two critical variables will be used to fulfil the management objectives of the model. These will be referred to as 'cultural' variables, and they are maps detailing protected locales along the west coast and the level of archaeological survey on the coast. From a Cultural Resource Management perspective it is important to know how many sites are located within National Parks, mining areas and industrial areas, and within areas controlled by various local authorities. Cultural Resource Management and management policy initiatives can then be directed at the authorities involved.

The coastline has undergone different levels of archaeological survey, such that what we know about the coast is not a representative sample. The implications of this bias are such that the model will seem to work perfectly for some areas because of the level of survey, and not so well for others. As a result the coast will be classified into two categories, Surveyed Areas and Unsurveyed Areas. The information for this variable will be determined from the survey maps from the Spatial Archaeology Research Unit, Archaeology Contracts Office and the South African Museum, which have most of the data about archaeology on the Cape West Coast. The information will then be entered on Geographical Information System (GIS) in order to determine whether certain areas were favoured for occupation by prehistoric people.

GIS is not merely a tool for making maps, but it is an analytical tool that can be used to solve an array of spatial problems. The ability of the system to join spatial and descriptive elements of a problem makes the system better than alternative systems like desktop mapping, computer-aided design (CAD), remote sensing, database management systems (DBMS), and global positioning systems (GPS) technologies. More on this will be said on the chapter dealing with GIS.

The first set of results will outline the basic characteristics of the coastline. Then the archaeological information will be analysed with the environmental variables to determine the components in each variable that seem to favour the location of sites. For example we might find that more than 80 percent of the known archaeological sites are located in areas with a particular geological substrate, which only forms 20 percent of the study area, hence one can suggest that the particular substrate attracted

prehistoric settlements. Once the process has been done for all the environmental variables we should have a fairly good idea what factor or combination of factors favoured the location of archaeological sites. The different factors will be weighted, and the weights from each category will be summed and used to obtain an Archaeological Sensitivity Model.

The results of this exercise will be a map indicating areas of varying archaeological sensitivity, rather than exact point data. The map will have implications for development and heritage management, and will include suggestions for mining companies for example, Anglo-American Corporation, Nature Conservation agencies, and for the Department of Environmental Affairs and Tourism (DEA&T) and local authorities. The model will be available in a compact disc format and in printed format as a series of maps covering the coastline. What is not clear at this stage is what sort of information will be made available to interested parties.

It would be ideal to verify the accuracy of the model by doing a survey of the coast, and then the results of the field test fed back into the system to improve the model even further. Given the many simplifications and assumptions that are part of any modelling exercise, it is imperative that sufficient tests are undertaken to test the accuracy of the model. Verifying the accuracy of the model can be done by surveying the study area to check the results of the exercise. Due to time and financial constraints it will not be possible to do a survey to test the accuracy of the model. What will be done is to use the results future research and Cultural Resource Management surveys to test the model. Afterwards the results will be incorporated to the model to improve its accuracy.

CHAPTER 2. GEOGRAPHIC INFORMATION SYSTEMS

The Geographic Information System (GIS) is a software system that handles spatially referenced data. It is primarily a database that has the capacity to integrate both spatial and non-spatial (attribute) data (ITS 1995). It makes provision for data capture, manipulation, query and display. GIS technology integrates common database operations such as query and statistical analysis with the unique visualisation and geographic analysis benefits offered by maps. These abilities distinguish GIS from other information systems and make it valuable to a wide range of public and private enterprises for explaining events, predicting outcomes, and planning strategies (Marble 1987).

The major challenges we face in the world today - overpopulation, pollution, deforestation, natural disasters - all have a critical geographic dimension. Whether siting a new business, finding the best soil for growing bananas, or figuring out the best route for an emergency vehicle all have a geographical component. GIS gives the power to create maps, integrate information, visualise scenarios, solve complicated problems, present powerful ideas, and develop effective solutions like never before.

GISs are closely related to several other types of information systems, but it is the ability to manipulate and analyse geographic data that sets GIS technology apart. Although there are no hard and fast rules about how to classify information systems, the following discussion should help differentiate GIS from desktop mapping, computer-aided design (CAD), remote sensing, DBMS, and global positioning systems (GPS) technologies. A desktop mapping system uses the map metaphor to organise data and user interaction. The focus of such systems is the creation of maps - the map is the database. Most desktop mapping systems have more limited data management, spatial analysis, and customisation capabilities. Desktop mapping systems operate on desktop computers such as PCs, Macintoshes, and smaller UNIX

workstations. Computer Aided Design (CAD) systems evolved to create designs and plans of buildings and infrastructure. This activity required that components of fixed characteristics be assembled to create the whole structure. These systems require few rules to specify how components can be assembled and very limited analytical capabilities. CAD systems have been extended to support maps but typically have limited utility for managing and analysing large geographic databases. Remote sensing is the art and science of making measurements of the earth using sensors such as cameras carried on aeroplanes, GPS receivers, or other devices. These sensors collect data in the form of images and provide specialised capabilities for manipulating, analysing, and visualising those images. Lacking strong geographic data management and analytical operations, they cannot be called a true GIS. Database management systems (DBMS) specialise in the storage and management of all types of data including geographic data. DBMSs are optimised to store and retrieve data and many GISs rely on them for this purpose, although they do not have the analytic and visualisation tools common to GIS (ESRI 1999).

GIS is a tool used by individuals and organisations, schools, governments, and businesses seeking innovative ways to solve their problems. Mapmaking and geographic analysis are not new, but a GIS performs these tasks better and faster than do the old manual methods. And, before GIS technology, only a few people had the skills necessary to use geographic information to help with decision making and problem solving. A typical basic GIS has four components, and they are (Marble 1987)

- "*A data input subsystem*" that allows the user to input spatial data from existing maps, photographs, and other mediums.
- "*A data storage and retrieval subsystem.*" that allows the user to store, retrieve and update the spatial data.
- "*A data manipulation and analysis subsystem*" that allows the user to do detailed analysis on spatial data.
- "*A data reporting subsystem*" that allows the user to display the original and manipulated data either in tabular or map form.

Knowing where things are and why is essential to rational decision making (Dangermond 1999). Hence the introduction of GIS into archaeological research has had two profound results. First, the use of GIS allowed for the uniform and consistent analysis of large areas. The second was the application of research approaches such as predictive modelling could now be affected over relatively large areas. Concurrently, the use of GIS introduced a range of considerations not traditionally a part of archaeological research. Issues surrounding digital data, cartographic theory, and general data integrity became an integral part of research design and strategy.

GIS offers the ability to automate entire processes during modelling exercises, the ability for rapid production of regional maps of model predictions. The ability to map regions at a high resolution. All these functions are made possible because the information is coded electronically, it is easy to update and improve. Therefore, GIS is not merely a tool for making maps, but it is an analytical tool that can be used to solve an array of spatial problems, hence it has often been referred to as "A tool in search of a problem." The ability of the system to join spatial and descriptive elements of a problem makes the system better than equivalent systems.

Background of GIS Studies in Archaeology

Studies in archaeology that incorporate GIS are somewhat more than a decade old. At the start GIS was used as an inventory tool, followed by its use in analysis, and the maturity stage was reached when GIS was used as an integrated decision-making system (Kvamme 1995). Being a relatively new field, innovations in GIS are taking place all the time. With the increasing power of current computer technology GIS applications in a variety of disciplines are likely to increase in the next decade.

The Geographic Information System has been used in producing maps on regional site distribution and spatial distribution of artifacts from occupation floors (Clark 1979; Kvamme 1995; Hivernel and Hodder 1984). Presently GIS is used for a variety of analyses, both at site level and at the regional level. At site level GIS is used as a

management tool, planning tool, analysis tool and a reporting tool. There are also instances where GIS has been used in database collection (Wentz 1997). Also, at the site level GIS is used in the simulation of artifact distribution (Bove 1981). At regional level GIS is used at spatial interpolation (Redman and Watson 1970), but it is at regional level that GIS has made a meaningful impact in archaeology. GIS is being used in the development of regional databases for site distributions. The nature of the system is such that it meets both the analytical and administrative goals of a project.

The Granite Reef project for example, was the first full-blown GIS application in archaeology (Brown and Rubin 1982). What this project did was clearly show the importance of GIS application in archaeology and introduced new analyses in the discipline. The Granite Reef project was the first archaeology project to make use of distinct data layers in dealing with the large volume of data. Furthermore distinct data layers were combined and map algebra techniques were used to derive new data layers like weighted layer combinations, and environmental suitability models (Brandt *et al.* 1992).

More sophisticated use of the GIS has been the use of Digital Elevation Models (DEM) to enhance pattern recognition by including *z-values* - height - in an otherwise 2-dimensional analysis (Green and Stewart 1983; Kvamme 1983). In addition it become possible to generate further layers from the DEM, like aspect and slope. Palaeo-environmental reconstruction (Tapia and Tapia-Recillas 1996) using GIS is also an emerging GIS application in archaeology. Other studies in archaeology have used GIS to try the differentiation of natural process *versus* human impact on the transformation of the environment (Tapia and Tapia-Recillas 1996).

Other areas where GIS has had an influence is in remote sensing by the use of environmental and geophysical data to enhance predictive modelling. Because human behaviour is patterned with some level of predictability, therefore the distribution of known sites will tend to show non-random patterning. That realisation makes it possible to predict the location of unknown sites, to some extent at least. Using GIS as a predictive modelling tool decreases exploratory period during survey, decreases

areas to be surveyed, often results in more effective use of resources, and finally increases reliability of discovering sites.

Predictive location models are based on the use of known patterns to project and predict location of unknown sites (Kvamme 1983). This form of analysis is useful as a research and a management tool, but it has mainly been used as a management tool in the sub-field of Cultural Resource Management (CRM) (Kohler and Parker 1986; van Leusen 1993). The use of predictive models has been more prevalent in the USA than in Europe - two regions where use of GIS in archaeology has been documented extensively. There are two main reasons why GIS in the USA made its first impact on CRM or Archaeological Resource Management (ARM), as it is often referred. First, funding opportunities have to some extent dictated where innovations and trends in archaeology are directed. The field of CRM being new and vibrant was fertile ground for introduction of new techniques. Secondly, GIS applications in CRM are similar to established GIS applications in related fields like land-use planning where there is a need to relate site distribution to management plans.

Computer simulation of archaeological conditions is another avenue where GIS has made major inroads. GIS has been used with environmental data to examine human land-use dynamically and the reasons behind it (Zimmerman 1977; Chadwick 1978; Chadwick 1979). In the northern part of Wetterau, Germany, research was conducted into the relationship of settlement and pedological condition - interdependence between soil quality and land use for agriculture (Saile and Zimmermann 1996). Further research in Europe has included modelling the structure of the cultural landscape. This has been essentially a European phenomenon because the archaeological data are temporally and spatially dense, as opposed to the USA. This was a move away from the deterministic nature of predictive modelling, more in the direction of representation of social landscape, i.e. the use of viewshed and multiple viewshed analysis, cost and effort surfaces, and combination of these (Harris and Lock 1995). Stoddart *et al.* (1996) used GIS to look at both the physical landscape - relationship between terrain and human occupation - and the cultural landscape, by the use of Thiessen polygons to investigate territorial boundaries. Other attempts at the

incorporation of the physical landscape and cultural landscape made use of viewshed analysis. Viewshed analysis is done by calculating the proportion of the landscape that is visible from a site and compare that with other site. This is done with a prior assumption that ritual sites tend to maximise visibility and minimise accessibility in order to increase their status.

All the above examples indicates that GIS has been used mainly in two areas as a data management tool, and a research instrument in palaeo-environmental and social landscape studies, and depositional processes. This is achieved through the use of GIS as a facilitator of spatial analysis, a mapping tool for regional spatial databases, and as a tool for predictive modelling (Kvamme 1995).

Issues for Consideration

The incorporation of a new technique in an already established discipline is not without controversy. There are theoretical and methodological issues to take into account before the use of GIS in archaeology is attempted and furthermore there are other issues related to the final product with regard its use and presentation.

Theoretical Issues

The main criticism of GIS-based archaeological studies according to Gillings & Goodrick (1996) is that they are “largely functionalist and deterministic, supported and encouraged by a battery of spatial statistical techniques firmly rooted in a hypothetico-deductive paradigm and committed to a normative and reductionist agenda of optimum site location studies and predictive spatial modelling.” In simple terms three issues can be identified within GIS-based archaeological studies that give particular cause for concern, Space and Time, Pointillism, and Determinism.

Another unresolved issue is how does one determine the value of archaeological resources? Cultural resource managers have to deal with this issue all the time, but there are no agreed upon criteria. Archaeological resources have an economic value, scientific value, and landscape value (van Leusen 1995), but there is no way to determine which of these should contribute in determining value of archaeological resources.

Space and Time

Currently we are lacking a truly temporal GIS, and space has fared even less despite the unique time-depth and spatio-temporal dynamic that characterises many archaeological data sets. In archaeological-GIS space is very much abstracted and de-humanised (Gillings & Goodrick 1996). Space is strictly Cartesian, universal, clearly measurable, and an external backdrop to cultural activity. In reality space has a cultural value, and GIS-based archaeological studies need to discuss more than just the choice of measurement units, specific map projections, *et cetera*, for space to be fully integrated in this emerging field.

The treatment of time in archaeological-GIS is prescriptive, and is characterised by an overly Cartesian viewpoint. Time is often incorporated in the form of a series of discrete snapshots moments. Time and space are rather a media and an outcome of human action rather than containers'. Steiner succinctly puts it when he says, "We do not live 'in time', as if the latter were some independent, abstract flow external to our being. We 'live time'; the two terms are inseparable." (Steiner 1992 : 78)

Pointillism

Critical research of archaeology is the study and conceptualisation of landscapes, the role of perception and relationships between people and the place they experience (Gillings & Goodrick 1996). There is tendency in GIS-based archaeological studies to reduce, abstract and simplify the full complexity of the cultural data being researched. For example, the representation of complex, socially enmeshed cultural landscapes

down to discreet points, because of their statistical suitability for spatial analysis. A tendency of reducing archaeological research into the making of 'making pictures'. A tendency to simplify the complexity of archaeological data and the restriction of research on the discovery of pattern in data, rather than explaining the pattern and understanding (Limp 1996). This is an inevitable product of a technique-driven trajectory (Gaffney & van Leusen 1995), which often leads to simplification and abstraction to suit the systems capabilities. We see in 3-dimension, there are sounds, shapes, sizes, textures, colours, volumes, and distributions. The multi-media nature of real-world data means that we need a system with capabilities beyond that which a current GIS can offer (Claxton 1995).

In an attempt to redirect applications of GIS towards a clear problem-oriented archaeological framework, researchers often find distinct inadequacies in the primary archaeological data (Miller 1995). There is a question mark regarding the adequacy of archaeological data collected not explicitly for GIS during a survey project, for GIS analysis. These problems often restrict the breadth and potential impact of the GIS-based studies, but on the positive side have forced researchers to re-think the nature and focus of archaeological data collection. What are archaeological resources? This is not a new issue but is the old 'site' *versus* 'cultural landscape' debate that has been fought between academic archaeologist and CRM practitioners (van Leusen 1995). This is further complicated by the representation of a site in most GIS systems as a point. Most sites cover wide areas and should rather be represented as a polygon, but this is not possible if the developer of the GIS system has access only to longitude and latitude values with no indication of the full extent of the site. Furthermore considering that the fundamental spatial building blocks of GIS systems are points, lines and polygons, archaeologists who used the system have to re-think the basic nature of GIS itself.

Determinism

Often archaeologist who make use of GIS in predictive modelling have been accused of deterministic modes of explanation especially when relating environmental factors and archaeology. Environmental determinism (ED) unequivocally posits that past

cultures are shaped by environmental pressures, and this assumes the pre-eminence of human economic behaviour as opposed to cultural behaviour. This is especially apparent when reading material by the adherents of New Archaeology and early Marxist archaeologists (Gaffney and van Leusen 1995). Inevitable this has led to the neglect of the ritual and cognitive aspects of site location, and the confirmation of obvious relationships. Once again this is not the problem of the GIS system, but is a result of misuse by the users.

There are instances where the environmental determinism approach is useful, for example with regard to cultural resource management the focus is on protection rather than understanding, and therefore environmental determinism approach is useful because of practical restrictions with time and money (Gaffney and van Leusen 1995). Furthermore the use of environmental determinism often leads to detection of patterns, non-patterned and random part of the archaeological record and eliminate environmental patterning. This approach eventually led to a clearer view of cultural factors. In addition the importance of cultural factors decreases with smaller scales (larger regions), therefore on a global scale human settlement is determined by climate, topography and other environmental factors. The same relationship holds up when dealing with the temporal scales (Gaffney and van Leusen 1995). van Leusen puts a counter argument that a successful CRM model should explain archaeological data entirely including both the original cultural and environmental factors, and the post-deposition factors. There is also inadequacy of GIS data layers with archaeological information in describing human settlement system, because they tend to coarsen the resolution of archaeological data.

A caution, the suggestions to remedy this functionalist and ecological bias are characterised by a somewhat dogmatic rejection of approaches focusing upon the 'natural' in favour of approaches that favour the primacy to the 'cultural'. There is an element of truth when Renfrew's (1982:11) says "if people's actions are systematically patterned by their beliefs, the patterning (if not their beliefs, as such) can become embodied in the archaeological record". Furthermore if the actual cultural variables are unmappable, hypothesis about cultural behaviour can be tested in a GIS

if they have a spatial consequence (Gaffney and van Leusen 1995). Therefore, the likely way forward is the integration of a culture-nature synergy.

Methodological Issues

General-purpose geographic information systems essentially perform six processes or tasks, Input, Manipulation, Management, Query and Analysis, and Visualisation. Before geographic data can be used in a GIS, the data must be converted into a suitable digital format. The process of converting data from paper maps into computer files is called digitising. Modern GIS technology can automate this process fully for large projects using scanning technology; smaller jobs may require some manual digitising (using a digitising table). Today many types of geographic data already exist in GIS-compatible formats. These data can be obtained from data suppliers and loaded directly into a GIS. Once the information has been converted into a suitable digital format it is likely that data types required for a particular GIS project will need to be transformed or manipulated in some way to make them compatible with the system used. For example, geographic information is available at different scales (detailed street centreline files; less detailed census boundaries; and postal codes at a regional level). Before this information can be integrated, it must be transformed to the same scale (degree of detail or accuracy). This could be a temporary transformation for display purposes or a permanent one required for analysis. GIS technology offers many tools for manipulating spatial data and for weeding out unnecessary data.

For small GIS projects it may be sufficient to store geographic information as simple files. However, when data volumes become large and the number of data users becomes more than a few, it is often best to use a database management system (DBMS) to help store, organise, and manage data. A DBMS is nothing more than computer software for managing a database. There are many different designs of DBMSs, but in GIS the relational design has been the most useful. In the relational design, data are stored conceptually as a collection of tables. Common fields in

different tables are used to link them together. This surprisingly simple design has been so widely used primarily because of its flexibility and very wide deployment in applications both within and without GIS.

Once you have a functioning GIS containing your geographic information, you can begin to ask simple questions such as : Who owns the land parcel on the corner where the archaeological sites are located? How far is it between two archaeological sites? Where is land zoned for industrial use that will have minimum impact on cultural resources? And analytical questions such as : Where are all the areas suitable for building new houses? What is the dominant soil type for Later Stone Age sites? If I build a new highway here, how will the conservation of archaeological sites be affected? GIS provides both simple point-and-click query capabilities and sophisticated analysis tools to provide timely information to managers and analysts alike. GIS technology really comes into its own when used to analyse geographic data to look for patterns and trends and to undertake "what if" scenarios. Modern GISs have many powerful analytical tools, but two are especially important, Proximity Analysis and Overlay Analysis. For example we might want to know : How many archaeological sites lie within 100 meters of this river? What is the total number of archaeological sites within 10 meters of the rocky shoreline? To answer such questions, GIS technology uses a process called buffering to determine the proximity relationship between features. Overlay Analysis refers to the integration of different data layers. At its simplest, this could be a visual operation, but analytical operations require one or more data layers to be joined physically. This overlay, or spatial join, can integrate data on soils, slope, and vegetation, or land ownership with the location of archaeological sites.

For many types of geographic operation the end result is best visualised as a map or graph. Maps are very efficient at storing and communicating geographic information. While cartographers have created maps for millennia, GIS provides new and exciting tools to extend the art and science of cartography. Map displays can be integrated with reports, three-dimensional views, photographic images, and other output such as multimedia.

How does a GIS do all of this? A GIS stores information about the world as a collection of thematic layers that can be linked together by geography. This simple but extremely powerful and versatile concept has proven invaluable for solving many real-world problems from tracking delivery vehicles, to recording details of planning applications, to modelling global atmospheric circulation. Geographic information contains either an explicit geographic reference, such as a latitude and longitude or national grid co-ordinate, or an implicit reference such as an address, postal code, census tract name, forest stand identifier, or road name. An automated process called geocoding is used to create explicit geographic references (multiple locations) from implicit references (descriptions such as addresses). These geographic references allow you to locate features, such as a business or forest stand, and events, such as an earthquake, on the earth's surface for analysis.

Geographic information systems work with two fundamentally different types of geographic models--the "vector" model and the "raster" model. In the vector model, information about points, lines, and polygons is encoded and stored as a collection of x,y co-ordinates. The location of a point feature, such as an archaeological site, can be described by a single x,y co-ordinate. Linear features, such as roads and rivers, can be stored as a collection of point co-ordinates. Polygonal features, such as lakes and river catchment, can be stored as a closed loop of co-ordinates. The vector model is extremely useful for describing discrete features, but less useful for describing continuously varying features such as elevation values. The raster model has evolved to model such continuous features. A raster image comprises a collection of grid cells rather like a scanned map or picture. Both the vector and raster models for storing geographic data have unique advantages and disadvantages. Modern GISs are able to handle both models.

Synthesis

Despite the theoretical shortcomings, GIS is not atheoretical (Wheatley 1995). There have been studies that attempted to break free from the environmental determinism dominating GIS applications in archaeology, which is in fact a product of our

interpretation (Llobera 1996). This study (Llobera 1996) tries to show that GIS can be a heuristic tool. Attempts at viewshed analysis represent attempts at cognitive archaeology (Gaffney and van Leusen 1995). Cumulative viewshed analysis (CVA) make inferences about the relationship of intervisibility between related sites within a landscape, thereby providing insights onto the role of a site within a society (Wheatley 1995).

There have been other attempts to integrate both the cultural and ideological notions of space. Gillings (1996) tried to show how GIS can integrate the cultural and ideological notions of space. This was done by the adoption of viewshed based analysis. This resulted in a 'technique led' approach because viewshed based technique of analysis ignores the auditory, olfactory and haptic senses. For a complete integration of cultural notions and ideological notions in GIS, we must realise that viewshed analysis is but a first step. Furthermore viewshed analysis will always be inadequate, because firstly the resolution of the Digital Elevation Model (DEM) is often not fine grain enough. Secondly, because our privileged external vantage point we have no idea how to experience impacts within the landscape.

Viewshed analysis is not without blemish, there are errors that are mainly due to four factors. First errors are caused by elevation values in the Digital Elevation Model. Secondly there are errors caused by the quantisation effects of rasterising the elevation model. Thirdly errors are due to interpolation errors introduced by the isoline to the Digital Elevation Model (DEM). Lastly errors are caused by the locational displacement of sites. These often lead to the propagation of secondary errors in individual viewshed maps, cumulative viewshed maps, and to the attribute values of sites (Wheatley 1995).

A word of caution the ones who do not use the technology are in danger of undermining their capabilities. The fundamental elements of archaeology are space, time and form, therefore any technologies that improve our understanding of these elements need to be embraced. For example look how radiocarbon dating has altered archaeology (Limp 1996).

Like all analytical tools, GIS is not without problems. The problems result from the system's inadequacies and also because of misuse by users. Firstly data input is error-prone, time consuming, inconsistent. This problem is exacerbated by the different thematic contents, scales, projections of commercial maps available (Claxton 1995). Even in cases where the input of data has been undertaken by an official agency or commercial agency, the data are usually not complete and standards are below the requirements for a scientifically sound project (Kvamme 1995). Secondly, because GIS is relatively new and is in its developmental stage, there is a lack of software or software is not readily available to the user to the same extent that word processors are presently. This is a sort of a problem that will disappear with new developments in computer hardware and software design. Thirdly the intellectual climate within archaeologist involved in predictive modelling favours deductive reasoning, whilst GIS promote pattern-seeking in empirical data, an inductive process. This problem is more the result of the misuse of the GIS system than a problem with the system itself. One way to go around this problem is a dual approach to spatial investigation, for example the use of visualisation - to effectively communicate results - and statistical analysis.

The requirements of the planning process are such that Cultural Resource Managers need to learn to speak the language of planners. Furthermore their plans must be easy to incorporate into local, regional and national plans.

Future Direction

Currently the central assumption in most Geographic Information Systems is that only present-day or single time frame data will be analysed. The discipline's maturity - archaeology - is indicated by increasing debates on the epistemological status of the Geographical Information System. The next goal is to develop a Temporal Geographic Information System (TGIS) with location-based, object-based, and temporal-based representation. For analysis of the huge time depth of human culture the value of a program with these capabilities is immense.

Spatiotemporal data analysis will enable archaeologists to examine change on a basis of time, retrieve locations on the basis of the temporal relationships of a specified event, examine the overall patterns of temporal relationships for a phenomena. The state of an object or location influences both its future state and is a reflection of past states. Therefore time representation is necessary so that change can be represented and be able derive cause and effect relationships from the observational data. The basic motivation for a TGIS is to provide an integrated tool for the analysis of spatiotemporal dynamics that corresponds to how humans conceptualise these dynamics.

The use of artificial intelligence (AI) is another area where GIS applications in archaeology can be improved (Reeler 1997). Artificial intelligence can be used to guide users in the selection of options during modelling exercises (Claxton 1995). In addition to the use of artificial intelligence will be the incorporation of neural networks and virtual reality to GIS simulation of archaeological data. Neural network systems are needed to transform, reformat, and rescale archaeological data sets, and facilitate ways to deal with error-prone aspects of data collection. That would be possible by the creation of map reading devices to overcome problems of scanning or digitising maps. The ability to mask or filter unwanted elements in a map, rescaling, reading and interpretation of thematic maps. Virtual reality will enable archaeologists to directly experience differing temporal processes, spatial relationships, and multi-dimensional real-world data generated in the evolution of the landscape. What these technologies offers is the prospect of advancing the ways of simulating past behaviour, and further enhance the important role of GIS in the discipline of archaeology (Claxton 1995).

Spatially GIS can visualise and analyse events in 2 dimensions (Miller 1995), although it is possible to generate 2.5-dimension or quasi 3-dimension graphics (Harris & Lock 1995). An example of these will be draping a 2-dimensional image like a soil map over a wire mesh generated from a digital elevation model (DEM). A truly 3-dimensional GIS will lead to better understanding of site structure, occupational history, stratigraphy. This will improve the recording and analysis of

archaeological phenomena *in situ* at intra-site level, the analysis of temporality at both intra and inter-site level. That is including gradual changes (linear), sudden changes (catastrophic) or non-linear changes. Furthermore a 3-D GIS will lead to the development of spatial statistics capable of heuristically seeking adjacency and other spatial relationship in 3-D simultaneously (Harris and Lock 1995).

One of the areas which current GIS is in dealing with issues of data, knowledge distortion, behaviouralism and “fuzziness”. GIS is not value neutral nor objective, because of biases generated by data selection, classification and GIS analysis (Reeler 1997). Most of the data used in GIS project at the moment are mappable data like soil or geology cover. This bias in data availability, hence selection is the cause of the environmental determinism emphasis apparent in most GIS applications in archaeology. There is a need to find ways of incorporating complementary behavioural data in the system. Furthermore there is no way to deal with the question of what constitute a site. Points on a map or even polygons do not seem to adequately represent a site (Harris & Lock 1995).

Multi-media in archaeological GIS is another area of innovation. The GIS system is so versatile such that it is possible to incorporate oral histories, photographs, moving images (Harris and Lock 1995). GIS-based simulation using multi-media will result in greater realism and insight. Archaeologists who are involved in GIS-based studies need to move beyond the simple Cartesian notion of space towards simple notions like cost-surface modelling and perception-aware studies (Gaffney & Stancic 1996). Cost-surface modelling studies have their failings as well in the sense that they take a functionalist adherence to ideas of cost and effort. They tend to assume that past people were rational, decision-making entities. Viewshed and visibility analysis studies also run the risk of conforming to the same reductionist, ‘technique-led’ agenda of the 1st generation of archaeological GIS application. They tend to confuse the concept of ‘vision’ with that of ‘perception’ for the sake of technical convenience (Gillings & Goodrick 1996).

The way forward is to broaden the definition of ‘perception’ not to define perception solely in visual terms, but to include the multi-sensual reception of information about

the world around us. This means taking into consideration things like memory, experience, education, and expectation. For GIS applications in archaeology to be truly sensual the system has to encompass visual (sight), auditory (sound), olfactory (smell) and haptic (touch) senses.

Summary

GIS: allows the integration of spatial and non-spatial data - spreadsheets and illustration packages - which was not possible in the past. This results in 2 dimensional modelling, 3 dimensional visualisation and new data layers and tables. Furthermore it permits statistical analysis because the mapping software can access and update tabular data in standard database forms, hence it supports the open-systems approach (Johnson 1996).

Furthermore GIS allows the enhancement of survey data collected with early techniques and thereby facilitates the answering of questions that were not possible before. First, GIS and computerisation in general increases the accessibility of data such that other scholars can explore alternative interpretations without time-consuming manual manipulation. Secondly, GIS can enhance data that were collected with varying levels of sophistication. Thirdly, because of varying data quality from different surveys verification of data is necessary, and this in a way is related to the enhancement of data (Stoddart *et al.* 1996).

One component of recording and preserving archaeological sites is the analysis of the effects past human activities had on the natural environment, and *vice versa*, or how the environment encouraged and hindered past human activities. This means projecting and evaluating interactions and cumulative impacts on many elements simultaneously. This requires an integration of observational data and environmental knowledge of a magnitude that has rarely been attempted. Also needed is an improved understanding of the processes involved on a much detailed and formal level, the

ability to predict resource response over a wide range of space and time scales, and, finally the ability to translate those predictions into a format upon which people can make decisions about the shape and content of future environments. All of the above require the analysis of change through time and of patterns of change through time.

By nature excavations are destructive, and that is paradoxical to the need of protecting and preserving sites. Secondly most of the time the ownership of where sites are located is private, yet the past is public property. Lastly protection of the past requires confidentiality, but the public need to have knowledge of the information. This means that there is a need for archaeologists to switch theoretical, methodological, legislative and educational roles. Archaeologists need to integrate management, research and education in order to enhance public stewardship of the past, while working within existing heritage legislation. At the same time they are dealing with three distinct audiences - professional community, students within and beyond university, and the general public. The Geographical Information System (GIS) offers ways and means to tailor large, complex data for these three not often complementary audiences. In the professional realm GIS will be used as tool for management, teaching and research, and in the public realm GIS will be used as a tool for advocacy, communication and education (Bampton and Hamilton 1996).

CHAPTER 3. PREDICTIVE MODELLING

“Predictive capacity without explanatory capacity is worthless. Mere clairvoyance irrespective of its sharpness, does not have scientific standing. Only predictive capacity that arises out of having coherent and communicable explanations has scientific standing. The power to predict is subsidiary to the power to explain” (Liebenstein 1976:13 in Kohler and Parker 1986:397).

Predictive modelling is a new field of research within archaeology that has gathered momentum over the past two decades. Predictive modelling in archaeology is defined as a

“...simplified set of testable hypotheses, based either on behavioural assumptions or on empirical correlations, which at a minimum attempts to predict the loci of past human activities resulting in the deposition of artifacts or alteration of the landscape” (Kohler 1988:33).

Introduction

An Archaeological Sensitivity Model (herein after ASM) is essentially a map indicating the relative likelihood of finding a site in a region. These maps indicate that some areas are more sensitive than others are in terms of the presence and nature of archaeological sites. If they are accurate, these maps have a huge potential as a planning tool, because their use decreases the cost of archaeological surveys in the long run and inform developers to cost implications. But the key factor here is accuracy. The accuracy of an ASM can be tested by comparing the model results to those of an actual archaeological ground survey. If the survey shows that most sites are found in areas indicated as highly sensitive by the model and few sites in areas of low sensitivity, then the model performs accurately. Model testing therefore is an essential developmental stage if we are to believe that the ASM is not a figment of the archaeologist's imagination.

Predictive modelling in archaeology has its basis in the settlement studies first carried out in the 1950s and 1960s. Willey (1953) conducted a study to examine archaeological data on a regional level in order to understand the processes inherent in settlement systems in the Viru Valley in Peru. At this stage predictive modelling operated within an inductive framework where research was based upon little or no theory. The technological developments and use of computers led to the ability to manipulate greater amounts of data and the ability to produce more detailed analyses.

The Southern Anthropological Research Group (SARG) anticipated the goals of many archaeologists when they sought to predict unknown site locations from the principles of the known settlement systems (Plog & Hill 1971). Their goal was to explain the "...variability in the distribution of prehistoric sites - settlement and limited activity sites. Why do we want to explain site location or settlement system patterning? ... The most important reason for explaining settlement locations is that we hope to arrive at tested and useful laws that can be used by social scientist *to predict site locations anywhere at any time, including the present and the future*" (Plog & Hill 1971 : 10 - 11, orig. emphasis).

Others who were involved in predictive modelling included Williams et al. (1973) who attempted to determine the proper set of environmental conditions that can predict the presence or absence of archaeological sites in central Nevada focusing on winter village placement. Another pioneering study was by Green (1973) doing settlement studies in the British Honduras (now Belize). The goal of this study was to explain the variability in settlement locations and the predictions were only a corollary goal. Not all archaeologists see predictive modelling as a necessary expense. Some archaeologists see predictive modelling as an expensive exercise to discover the obvious, and they regard them as being suspect or unreliable or being limited in value (Kohler & Parker 1986).

The three pillars of any modelling exercise are information, method, and outcome (Warren 1990). Information may either be theories explaining the effects of variables on the events of interest or empirical observations, but in practice tend to be both theory and observation. Method is the statistics used to transform a body of

information into a model, and there are various methods used but the most common is regression analysis. The method used also influences the level of prediction of the third component of a predictive model, that of the outcome. The outcome can be one of four, each a function of level of measurement - nominal, ordinal, interval and ratio scales. Nominal predictions allocate sites to categories, i.e. vegetation, soil, geology, with no inherent ordering of sites. Ordinal predictions are on a higher scale of measurements than nominal predictions, because they have the ability to give a rank order to all categories according to a common criterion. Ordinal predictions do not give the exact magnitude of sites, but a ranking like high, medium and low. Interval predictions do everything the former predictions can do and furthermore allow ordering of categories relative to one another and the exact distance between them. The only drawback is the fact that there is no absolute zero point and therefore it is impossible to manipulate scores as ratios or interpret them as probabilities. Last but not least there are ratio-scale predictions. Ratio-scale predictions have all the attributes of interval predictions and furthermore they have an absolute zero point, and that means the predictions are easily verified by sample data (Warren 1990).

Methodology

There are two types of models used in archaeological predictive modelling. They are empirical correlative or inductive that are based on recognition of patterns or on conformities in empirical observations, and deductive models that are often derived from theory and focus on human choices (Kohler & Parker 1986). There are problems associated with both forms of modelling.

Inductive models form the basis of most predictive models, and begin with observations and then build conclusions based upon all the biases inherent in the original set (Dalla Bona 1994). Problems with the data sets can be that the site location information is incorrectly recorded, environmental information recorded in too little detail, missing data, varying quality of data by different researchers, and other systematic errors. As a result with inductive models there is a perpetuation of the original biases into the resultant model. Inductive models which are based on

empirical observations always perform better when a probabilistic sample is used instead of the entire archaeological record. This is because elements of bias caused by the uneven or incomplete archaeological record are likely to affect the model. Nevertheless there have been successful attempts at modelling using the entire existing record (Brandt *et al.* 1992). Furthermore the bias can be decreased by testing the model with independent data and adjusting the results if necessary. Another way to improve inductive models is by dividing site data into temporal and functional types, and by careful consideration of choice of environmental variables to use in the modelling exercise (Kohler & Parker 1986). Dividing site data into temporal types is necessary because environmental variables that influenced site location during the Middle Stone Age are likely to be different from those that influenced site location during the Later Stone Age. Functionally, a stone knapping site will have different environmental considerations to those of a butchery site.

Deductive models begin with a theory predicting human behaviour (Kohler 1988). Attempts at deductive models tend to assume rational human behaviour based on the cultural and biological needs of society, and the ability to imitate the judgement processes of people in the past (Dalla Bona 1994). They are based on a hierarchy of conditional arguments, for example by creating dichotomies of environmental variables as either favouring or not favouring settlements (Kohler & Parker 1986). Deductive models often leads to a vast series of hierarchical decision trees, which are then applied to archaeological data. Questions are always asked about their attempt to assume rational human behaviour because archaeologists do not know the thought processes that were taking place. Did people utilise multiple variables or a few key ones? Does the archaeological record tell us about these decisions? There is no way to account for habit and politics. How did past people assess risk and returns? Do we understand the goals of precolonial non-western people fully?

Inductive and deductive models both have a role to play in archaeological predictive modelling. Deductive models can be developed without empirical data, but will use site locations to test the validity of their outcome. Furthermore, deductive models are optimistic given the current state of archaeological theory, with little known about

human locational behaviour. Equally, inductive models developed with no theoretical input would be inefficient and have a weak outcome (Warren 1990). In addition, inductive models have problems with defining locational variables in terms of current rather than past environments. The environment during the occupation of the landscape being researched may have been vastly different to the current environmental conditions, therefore the outcome of the modelling exercise might give inaccurate predictions (Dalla Bona 1994).

In addition to the inductive and deductive theoretical frameworks, the methodological approaches used in predictive modelling may be separated into two groups, the numerical approach and the graphical approach (Dalla Bona 1994). The numerical approach is a direct outgrowth of the emphasis placed on the statistical analysis of archaeological data. The numerical approach employs multivariate statistics to identify associations, and assumes that the known archaeological site information is representative of the actual sites that exist. In order to use the numerical approach there are three issues that an archaeologist needs to consider. First, the archaeologist needs to consider the representativeness of the sample. Secondly, whether site location reflects the distribution of cultural resources or where archaeologists have surveyed. Thirdly, whether the physical environment has changed, in which case the changes could have affected the choices of activity locations (Kohler & Parker 1986).

In addition predictive models that employ the numerical approach require a high degree of statistical competence in order to develop, interpret and validate the results, something at which most archaeologists are not good at. The graphical approach is a direct consequence of technological developments in the 1980s. This approach uses map overlays with the help of the GIS to identify areas spatially associated with valued landscape characteristics (Dalla Bona 1994). Then the apparent associations are evaluated using statistical techniques. The difference from the numerical approach is that with the graphical approach statistics are used to evaluate the strength of association between environmental variables and archaeological, instead of establishing the association. The advantage of the graphical approach over the

numerical approach is that the researcher is able to identify the landscape features that are associated with both the significant and insignificant proportion of the archaeological data. As a result it is possible to highlight the minority of archaeological sites that are situated in unlikely landscapes. Then this subset of minority sites is used to determine patterns of association with different landscape variables in order to identify the types of sites, land use strategies, and idiosyncratic behaviour presently unknown. Then by re-focusing research to identify these anomalies the researcher unearths new information of a different order.

In archaeological modelling studies, the unit of investigation is a parcel of land. In order to have a parcel of land, the study area is either taken as a single unit or is subdivided by superimposing a regular grid over the area. These parcels of land are used to determine if there is any association between the presence and absence of archaeological resources - dependent variables - and the non-archaeological characteristics - independent variables - of the parcel.

The size of the units within a study area needs to be the same, but between projects they can vary depending on the resolution of the model. Generally for fine-grained models the units need to be small but can be large when the intention is to recognise broad regional trends. The ability of computer resources is another important consideration when deciding upon the size of the units, because when the units are small it may burden the functioning capacity of the computer.

The goal of CRM projects is to conserve archaeological resources and to assist developers in limiting costs by identifying areas with and without archaeological resources. This is done without taking into consideration the nature of the resources themselves. The most used dependent variable is the simple dichotomous case of 'presence' (S) and 'absence' (S'). This has the advantage of minimising complexity by focusing on defined events that form a mutually exclusive, exhaustive and non-ambiguous partitioning of the region and producing a large sample. Furthermore it allows the incorporation of data that was collected from different surveys. This is different from an academic project where the goal is to model locational behaviour of

different functional, chronological, and cultural types of occupation. Also the approach to be used depends on the fact that there are locational tendencies that are common to all functional and cultural categories. For example, proximity to water, level ground, and other factors. Nevertheless this does not cater for all situations. What about caves or overhangs? By using a Digital Terrain Model it is possible to identify areas likely to house such locations, but it not perfect.

Most independent variables used in modelling tend to focus on the economic determinants of site location. This is the case because environmental factors are considered to be intimately related to the locational decisions made by pre-colonial hunter-gatherers. What this means is that for these people the regional environment is where most important economic transactions took place. It is assumed that prehistoric people tended to minimise the time and effort needed to perform economic actions. These two assumptions are likely to be of no importance for complex societies or any society involved in a market economy, and the model can therefore only apply to prehistoric people.

The environment is crucial to human survival although people are able to adapt to a certain extent. Adaptation has been facilitated by technological developments, which were not available for much of human history. Archaeological predictive modelling is based on the assumption that sites tend to occur in specific environmental locations that favoured human occupation, and that these environmental circumstances can be identified. Predictive modelling is used as both a research tool and in the field of Cultural Resource Management (CRM). As a research tool archaeological predictive modelling is used to augment existing databases so as to understand archaeological potential in areas and regions that still have to be surveyed. In the field of Cultural Resource Management predictive modelling is used to facilitate planning and as a policy device. Recently there have been rapid developments in predictive modelling that have been encouraged by developments in computer technology, which have made the handling of large sets of spatial data easier.

The environmental variables considered for most predictive models have a physical element: slope, soil type, elevation, and plant community type, are all relatively easy

to measure through observations made from maps. The predictive model therefore works by correlating the location of known site with the environmental characteristics of the land parcel they are in, in order to predict the presence of sites in other land parcels with the same or similar characteristics. Ideally it is useful to use variables that are stable over a long time, like elevation, slope, and aspect, but it is permissible to use a proxy measure for variables like plant communities, water table elevation although they are extremely sensitive to climatic changes. The proxy measure that can be used with minimal effort are present day plant communities and water table elevation.

The number of variables and the choice of which variables to use depend on a number of factors. The environmental variables useful for a model depend on the area being modelled and cannot be determined completely a priori, and as a precaution it is better to use a large number of variables. During the modelling process these will be filtered out based on the strength of their predictive power. Variables with low predictive power will be discarded throughout the development process.

But how do predictive models work? Predictive models are based on the assumption that settlements choice and human activity is non-randomly distributed. And there is a significant regional patterning in the distribution of archaeological sites. This assumption requires a complex statistical examination of environmental variables to isolate patterns and differences between different types of locations. The results of the statistical examination are then used to formulate decision rules about the presence or absence of archaeological sites in a region. The statistical results will assign weights to all significant environments variables, and all cells in the grid will have values between 0 and 5 - indication of archaeological potential. The results will be a map called a probability surface, showing areas with similar and dis-similar probabilities.

For example, imagine the task of developing a model for modern-day camping location. From a theoretical perspective we can ascertain that good camp sites are located near water, on level ground, with a south-east aspect - to capture the sun's warmth-, near trees - as shelter for wind-, on a raised setting to provide a good view. The same answers can be gathered by interviewing present-day campers. By using

mapping facilities within the Geographical Information System, we can produce a map indicating highly favourable, moderately favourable and unfavourable areas for the location of a campsite. The same procedure can be used when developing a model of prehistoric people. The only difference being the fact that interviews and questionnaires cannot be used to determine what variables to use in the development of the model. The next best thing to use would be the archaeological resources at our disposal. Taking a sample of these archaeological resources we can attempt to determine which variables were important for prehistoric people. For example we might determine that the Later Stone Age people prefer a particular vegetation type, near water resources, and a south-sloping area. This technique is referred to as "pattern recognition", and it is through this process that the past is made to "speak to us". Once the pattern has been recognised what is left is to extrapolate this over a large region and produce predictive maps.

Issues For Consideration

The primary goal of most predictive models is to determine which combination of landscape variables produces the greatest likelihood of resource presence and absence. The variables vary in scale and nature - some are continuous for example slope and aspect and others are discrete for example vegetation types, geology or soil.

Most accurate cultural predictive models are based on information gathered with probability-based search procedures. This is because they use randomly located units to reduce bias in favour of surveyed units. On the other hand inductive models tend to assume that the distribution of known sites is a reliable guide, but forgets the fact that most known sites are large sites located near rivers and lakes. Furthermore the greater mobility of early people who camped and travelled long distances means that some of their sites are small and are likely to be unreported by landowners or people who come across the sites. Also if we only consider known sites we fail to learn the characteristics of areas that were not occupied - which is vital information for resource

planning. But in spite of the theoretical soundness of a probabilistic approach, it is often not practical because of financial and time constraints.

For a number of reasons, most predictive models are flawed because they fail to incorporate the location of buried sites- they lack the third dimension - and their lack of the cognitive aspect of past behaviour. "Although this "empirical correlation" procedure must by necessity be used in the formation of predictive locational models today, the importance of social and political factors in the spatial location of settlements cannot be ignored. Their identification should become an important focus of the modelling process as more is learned about the archaeology of the state." Furthermore the fourth dimension - temporal dimension - is often not incorporated during the construction of the model. And that is a major setback because sites have different significance based on their age and rarity. These dimensions can be incorporated in the models in the form of thematic layers that map the distribution of sediments that may or may not contain buried archaeological sites.

Developing a Predictive Model

There are four major steps in creating a predictive model that really works (Dalla Bona 1994). First, one needs to assign weight to different areas based on statistical results for the environmental variables. Secondly, one make the sensitivity model by making a map which is a composite of all map layers. The map should illustrate the results of the statistical analysis.

The third step is to assess the performance of the model. How accurate the model and how to assess the accuracy of a model are essential concepts that need to be looked into. The accuracy of a model is determined by comparing the results of the model and the actual circumstances - that is if for example out of 100 known sites (random sample), 85 of them fall within the zones flagged as being either high or medium then the model accuracy rate is 85 percent. The 15 percent error must be expected and allowed because no model is perfect. In most models errors are largely due to the fact

that locational models will tend to be biased toward the archaeological pattern of sites on or near the surface and those of recent age. The use of a multi-dimensional model that uses paleoenvironments will help to mitigate this factor. In addition to accuracy, a good predictive model needs to be precise. That means that if a model has an accuracy rate of 85 percent, at the same time it must map substantially less than 85 percent of the landscape to medium to high archaeological sensitive zones.

The last step, and one that should go on as long as the model is being used, is model refinement and implementation. The creators of the model must undertake a demonstration of the model use in actual CRM projects. Furthermore they must fine-tune the model to higher resolution if that is possible. Also it might be necessary to conduct training sessions for potential users, presentation of user-friendly GIS-based model, that is easily incorporated into planning process, and updateable. This requires an Arcview application, the environmental layers used to create the model, a layer of archaeological sites, and layers of model results - maps, colour coded to indicate areas of high , medium and low probability of finding archaeological sites. The model can be mapped either as a continuous surface of varying archaeological sensitivity or as zones with medium and high potential areas. Other formats will include paper maps and the use of a variety of presentation formats will increase utility of the model for all management agencies in the region.

Summary

Predictive modelling is primarily used to identify the locations of prehistoric settlement activity. The basis of predictive models are settlement pattern analysis that were first started in the 1970s and they continue to fulfill the aims of settlement pattern studies. Theoretically, predictive models can operate within either an inductive or deductive framework, or an amalgamation of the two frameworks. Methodologically there are two approaches, a statistical approach and a graphical approach. The latter is the indirect results of recent developments in computer technology that make it easy to handle large volumes of data and visualise the results easily.

Currently predictive modelling has had a major impact in Cultural Resource Management - a sub-discipline of Archaeology. The full potential will be reached when archaeologists realise the importance of predictive modelling as an academic research tool. In order for predictive modelling to fulfill its potential the evaluation scheme of the importance of archaeological resources must be clear, simple and robust. Clarity is attained by keeping factors involved in evaluation low, simplicity and speed is attained by the standardisation and customisation of GIS procedure, and robustness is attained by the applying a fixed set of evaluation rules. Furthermore rules must take into account the intrinsic value of the resource and the amount and type of danger, and that the value of archaeological resources are relative - they increase if similar resources are destroyed and decrease if similar resources are discovered in the vicinity.

CHAPTER 4. INFRASTRUCTURE

The purpose of this chapter is to look at the artificial environment in the study area that has an influence - negative and positive - on cultural resources. Artificial environment refers to both tangible and non-tangible infrastructure that may have an effect in the conservation of cultural resources. The first section outlines the threat that face cultural resources in the study area. Followed by an outline of positive aspects of the artificial infrastructure. Last but not least, the chapter concludes by looking into the current legislation that protects cultural resources and any new developments.

The Threat

There are generally two major sources of impact on archaeological resources. Primary sources and Secondary sources (Halkett & Hart 1997). Primary sources are large scale activities, which change the landscape, and they refer to :

- **Development of land - as a structure plan and rezoning application.**
- **Establishment of townships and resorts.**
- **Mining and quarrying.**
- **Flood control schemes and river diversion.**
- **Agricultural activity.**

Secondary sources are as destructive as Primary sources, and they are a direct results of human activity when development are close to cultural resources. The Secondary sources of impact are :

- **Illegal collection of artefacts.**
- **Establishment of informal parking areas, footpaths and camp sites.**
- **Dumping.**

At the moment mining, agriculture, re-zoning and the spread of urban communities present the three greatest threats to cultural resources. Ironically these three uses are also the ones that have led to the discovery of many archaeological sites. Cultural Resource Management initiatives on the Cape West Coast came into being by new mines opening, new residential areas being built, construction of roads, and re-zoning of land parcels. All of these human activities have different impacts on archaeological resources, that require distinct management strategies.

The area between the Orange River and Olifants River can be characterised as being heavily impacted by mining activities. During mining operations trenches expose and damage buried archaeological material. This is despite the fact that cultural resources are protected under the Minerals Act (Act 50 of 1991). According to the Minerals Act all mining projects must have environmental management programmes and before any mining activity must report on all cultural resources affected by the planned action. This does happened and a number of Cultural Resource Management projects have been done on large areas of the Cape West Coast that were going to be mined (Hart & Halkett 1997). Sometimes there are positive spin-offs with regard the conservation of cultural resources from mining activities. Mining companies like De Beers Consolidated Mines Ltd. acquired large tracts of land at the turn of the century with the purpose of utilising them in the future. For some of the areas that did not happen and they are unlikely to be mined in the future either, but because of the restrictions on access to this land these areas are almost pristine. All the resources, both cultural and natural, have not been negatively impacted by 20th century development that has destroyed other resources. Nevertheless the threat posed by mining activities is real and its results catastrophic.

South of the Olifants River all the way to the Berg River the major activity that impacts archaeology is agriculture, and to a lesser extent residential and industrial development. Buried archaeological sites are sometimes exposed during ploughing of fields. Some farmers have the necessary knowledge and usually inform the relevant authorities. That is not always the case, and if the finds are not reported they eventually get destroyed without any proper recording. Furthermore this part of the

country is very popular with holiday makers, who often build vacation houses near the coast. These residential developments are usually located on the dunefields near the immediate coastline, hence on top of prehistoric shell middens. In addition to the damage caused by construction of houses, the building of roads, water-pipes, and dams has a detrimental effect on archaeological sites. These - dams - are often built in catchment areas result in the destruction of archaeological sites that are located in the area. In the study area 3740814 square meters - 0.02 percent - has been dammed. That figure might seem insignificant, but the dams are located largely in areas that were suitable for human settlement in the past.

Woeful and senseless destruction of archaeological sites is another threat that is result of human activities. Rock art sites located near urban areas or roads are often destroyed because of inadequate protection. Graffiti is a common phenomena in many archaeological sites. The agencies responsible for the protection of these archaeological sites are unable to prevent this damage due to insufficient resources. Until people are educated and learn the responsibility of taking care of their own past the current trend is likely to continue.

South of the Berg River to Milnerton Lagoon residential and industrial development is a major activity. The development of townships and new manufacturing plants result in the destruction of valuable archaeological material. In the future this part of the Cape West Coast is likely to be under increasing pressure from development as a result of the Reconstruction and Development Project (RDP) - the Government's poverty alleviation policy. Furthermore, industrial development that is taking place in this area will have a negative effect on cultural resources. The Saldanha Steel Project and other satellite industrial developments are just few of potential threats to cultural resources.

Map 2 (in Appendix C) shows part of the study area that are built-up for both residential and industrial development. The coverage detailing Built_up Areas in the study area was extrapolated from the 1:50 000 topographical series available from the Chief Directorate : Surveys and Land Information. There is no gaurantee that this information is completely up to date because of the dynamic nature of developments

in the study area. The maps are 3 years old and since then new township development, industrial villages and mining activity has taken place. Despite these shortcomings it is felt that the information is enough to address the effects of residential and industrial development regarding archaeological sites. At present about 89.595 km² - roughly 0.5 percent of the study area, is built-up. This figure is constantly increasing as more areas are being developed. The bulk of the already developed land is located south of the Berg River - about 86 km². Major centres include Blouberg, Melkbos, Atlantis, Vredenburg, Velddrift, and Lamberts Bay north of the Berg River. The area further north has a few small built-up areas located along the coast, but the main activities are mainly agriculture and mining.

Protected Locales

It is worth stressing that it is not all gloom and doom. There are sectors within the study area, which are protected from development, or have experience limited human impact (see Map 3 in Appendix C). Nevertheless, these areas are still impacted by humans in the sense that roads, powerlines, houses, and other amenities are developed inside the boundaries. The difference is the fact that whatever development takes place is controlled. Various laws and regulations are in place to manage these areas. Although these areas are protected from development for reasons other than conservation of archaeological resources, that protection is extended to any site that falls within the boundaries of the area.

In all cases the reserve boundaries were matched wherever possible with the cadastral boundaries obtained on GIS from the Surveyor-General. The goal was a correspondence to within 5 metres between the reserve boundaries and the cadastral except in the case of (a) boundaries along rivers and the coastline (where the cadastral boundaries are unsurveyed and generally very inaccurate), and (b) unsurveyed reserve boundaries (notably boundaries of Demarcated State Forest between CNC reserves and SAFCOL plantations). The accuracy of most of the reserve boundaries therefore depends on the accuracy of the cadastral boundaries.

First there are conservation areas under the control of Cape Nature Conservation, known as Provincial Conservation Areas. The Cape Nature Conservation controls conservation areas that are proclaimed under various statutes, viz.

- Wilderness Areas Forest Act no. 122 of 1984 (section 15).
- Nature Reserves Forest Act no. 122 of 1984 (section 15).
- Demarcated State Forests Forest Act no. 122 of 1984 (section 10).
- Marine Reserves Sea Fisheries Act no. 12 of 1988.
- Islands Cape Nature and Environmental Conservation Ordinance no. 19 of 1979 (article 6);

Proclamation no. 23\1988.
- Provincial Nature Reserves Cape Nature and Environmental Conservation Ordinance no. 19 of 1974 (article 6).

At present there are 5 Provincial Conservation Areas that have been proclaimed in the study area (see Map 3 in Appendix C). The digitising of the Provincial Conservation Areas boundaries was undertaken by GIS laboratory in 1995 from the boundaries plotted on the published 1:50 000 topographical maps. Table 4.1 below list the Conservation Areas with the area they cover in square kilometres. In total, 47.74 square kilometre of the study area is under the protection of Cape Nature Conservation.

NAME	Area (in km ²)
Lutzville	15.841
Rocherpan	9.295
SAS Saldahna	9.309
Blouberg	7.173
Elandsbaai	6.131

Table 4.1 Protected Locales Under Cape Nature Conservation.

Secondly, parts of the Cape West coast have been declared National Parks or have been earmarked for that purpose in the future. Knowing how many and what kinds of archaeological sites are within National Parks will help facilitate their effective management. In the first instance development within National Parks is restricted, so that the chances of archaeological sites being impacted is significantly reduced. Secondly, if archaeologists know how many and which sites fall within national parks, they can inform park authorities who can then act as custodians for the sites.

Currently there is only one National Park that is within the boundaries of the study area, that is the West Coast National Park (see Map 3 in Appendix C). The West Coast National Park covers an area of 259.778 square kilometres - 1.6 percent of the study area. The data on National Parks is very much still incomplete. National Parks Board must still verify the accuracy of the data. There are future plans to proclaim a second National Park on the area between the Spoeg River and the Groen River. That would result in a dramatic increase in the parts of the study area that are under protection.

Thirdly, there are South African Natural Heritage Sites (Table 4.2). These Natural Heritage Sites are registered by the Department of Environment Affairs and Tourism (DEA&T) and are mostly privately owned (see Map 3 in Appendix C). The Department of Environment Affairs and Tourism (DEA&T) provided the information

in a GIS format in 1996. The data is still very incomplete and the boundaries very inaccurate. The area they cover is very small, only 4.992 square kilometres - a mere 0.03 percent of the study area. They are Plattekloof 430 - 2.49 square kilometres, Altydgedacht - 0.289 square kilometres, and 9 Divisie HK(Ou 6BKD) - 2.206 square kilometres (Table 4.2).

NAME	Area (in km ²)
Plattekloof	2.49
Altydgedacht	0.289
9 Divisie HK	2.206

Table 4.2 South African Natural Heritage Sites.

Despite the small area that these sites protect, they are likely to play an important role in the conservation of our heritage, both natural and cultural. These properties are owned by individuals or corporations, and are protected under the law from any development due to rare and sensitive habitats that they support. For example, Plattekloof protects an endangered plant species - *Serruria ciliata* - part of the Acocks Veld Type 47 (Coastal Fynbos). Indirectly any archaeological sites found within these properties are protected.

Fourth, there are RAMSAR sites. The Convention on Wetlands is an intergovernmental treaty adopted on 2 February 1971 in the Iranian city of Ramsar. Ramsar was the first of the modern global intergovernmental treaties on conservation and wise use of natural resources, encompassing all aspects of wetland conservation and wise use, recognizing wetlands as ecosystems that are extremely important for biodiversity conservation and for the well-being of human communities (RAMSAR 1996). Within the study area there are six areas that have been proclaimed as RAMSAR sites (Map2). They are the Orange River Mouth Wetland, Verlorenvlei, Langebaan, Langebaan-Marcus Island, Langebaan-Malgas Island, and Langebaan-

Jutten Island. Table 4.3 outline the RAMSAR sites within the study area and the respective extent of the area they cover in square kilometres. In total the RAMSAR sites cover 93.3366 square kilometres of the study area.

NAME	AREA(in square kilometres)
Verlorenvlei	14.489
Langebaan - Marcus Island	0.165
Langebaan - Malagas Island	0.184
Langebaan - Jutten Island	0.43
Langebaan	55.096
Orange River Mouth Wetland	23.002

Table 4.3 RAMSAR Sites Found in the Study Area.

Lastly, there are Local (Authority) Nature Reserves. Local Nature Reserves in the Western Cape Province are proclaimed in terms of the Nature Conservation Ordinance no. 19 of 1974 (article 7). The reserves are owned and managed by Local Authorities (Municipalities, Transitional Councils and Regional Services Councils). Map 3 (in Appendix C) show all the Local Nature Reserves that fall within the study area. They are Columbine, Durbanville, Tygerberg, Tygerberg (Parrow), Tygerberg (Bellville), Raapenberg, and the Rondevlei Bird Sanctuary. For Local Authority Reserves the digitising of the original maps was mainly undertaken by Forestek (CSIR) in 1993/94 and the GIS section at the Western Cape Department of Agriculture (Elsenburg) in 1996 from a set of 1:50 000 maps that were supplied by Cape Nature Conservation. These maps were accurately drawn in 1987 from the original maps that record the boundaries of the reserves when they were proclaimed. These original maps are held in CNC's Cape Town office files. Subsequent additions and corrections were made as new reserves were proclaimed or boundaries have changed. The Land Affairs section of the CNC supplied additional maps of recently proclaimed reserves in May 1997.

Table 4.4 outline the Local Nature Reserves and the extent of the area they cover in square kilometres.

RESERVE NAME	AREA(in square kilometres)
Columbine	2.569
Durbanville	0.065
Tygerberg(Parrow)	1.45
Tygerberg(Bellville)	0.658
Raapenberg	0.196
Rondevlei Bird Sanctuary	1.353

Table 4.4 The Local Nature Reserves in the Study Area.

In conclusion, about 412.146 km² of the study area is under some form of protection from development - roughly 2.6 percent of the study area (See Table 4.5). The reasons for the protection vary but by in large they have something to do with the natural environment of the areas. Nevertheless, the mere fact that these areas are protected from unmanaged development is a positive point. The various conservation agencies and proportion of land under their care is also illustrated in Figure 4.1. The National Parks Board is by far the largest curator of protected land in the study area, and that is likely to increase in the near future with the possible proclamation of a new National Park between the Spoeg River and the Groen River.

Management Authority	Number of Protected Areas	Area (km ²)	% Of Total Area
CNC	6	47.749	11.6
NPB	1	259.778	63
DEA&T	3	4.992	1.2
RAMSAR	6	93.3366	22.6
Local Councils	6	6.291	1.5
TOTAL	22	412.146	100
TOTAL % OF STUDY AREA UNDER PROTECTION			2.6

Table 4.5 Various Management Authorities Operating in the Study Area.

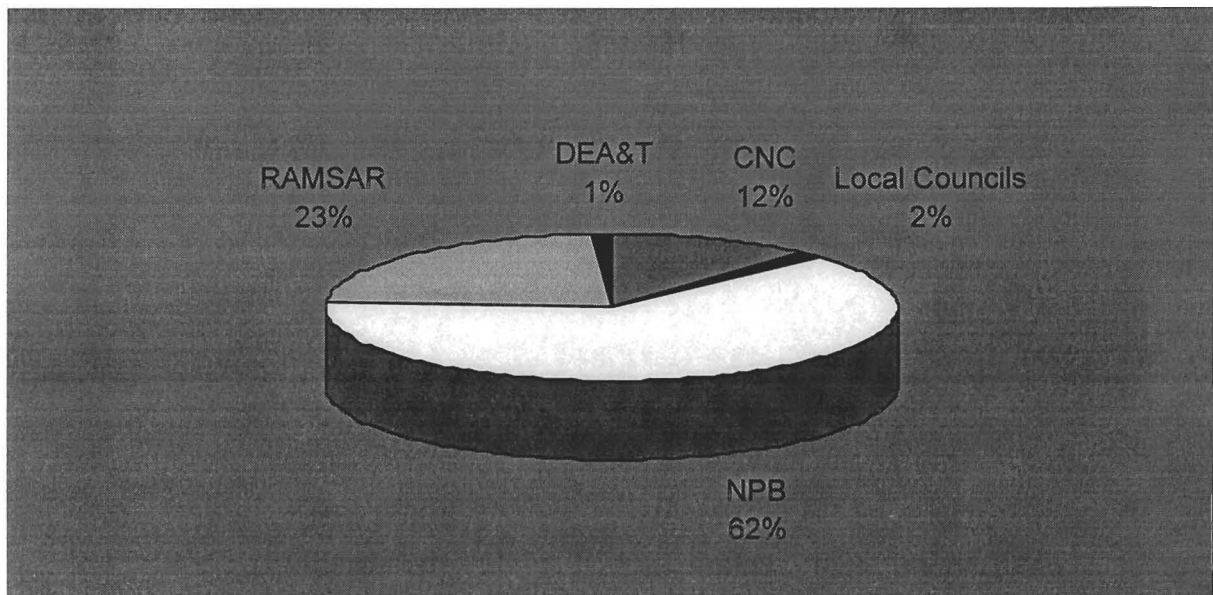


Figure 4.1 Proportion of Land Under Various Conservation Agencies.

Current And Future Legislation

The National Monuments Council was created in 1969 by an Act of Parliament and was invested to protect archaeological, palaeontological, and historical sites and structures. The legislation responsible for the conservation of archaeological sites is the National Monuments Act (Act 28 of 1969). Since the Bill was passed through Parliament in 1969, there has been a number of amendments to the Act the last being in 1986. At present the legislation is known as the National Monuments Act No. 28 of 1969 (as amended).

The relevant clauses of the National Monuments Act which apply specifically to archaeological resources are as follows:

Section 12 (2A) *No person shall destroy, damage, excavate, alter, remove from its original sites or export from the republic-*

a) any meteorite or fossil; or

b) any drawing or painting on stone or a petroglyph known or commonly believed to have been executed by Bushmen; or

c) any drawing or painting on stone known or commonly believed to have been executed by any other people who inhabited or visited the Republic before the settlement of Europeans at the Cape; or

d) any implement, ornament or structure known or commonly believed to have been used or erected by people in paragraphs (b) and (c); or

e) the anthropological or archaeological contents of graves, caves and rockshelters, middens, shell mounds or other sites used by such people; or

f) any historical sites, archaeological or palaeontological finds, material or object;

except under the authority of and in accordance with a permit issued under this section.

Section 12 (2B) *No person shall destroy, damage, excavate, alter, remove from its original site or export from the republic-*

e) any burial ground or grave referred to in section 3A (2)

except under the authority of and in accordance with a permit issued under this section.

Section 12 (3)(a) *The provisions of subsection (2A) shall apply to the removal of anything other than deposits in any cave or midden, in the normal course of mining, engineering or any agricultural activities: Provided that anything referred to in section (2A) is found in the normal course of the said activities, the finder thereof or the owner of the land where it is found or the person who performs such activities, shall report the fact immediately to an institution referred to in the Cultural Institutions Act, 1969 (Act No. 29 of 1969).*

Other relevant Acts with regard archaeological resources are the Environment Conservation Act (Act 73 of 1989) and the Environment Conservation Amendment Act of 1992. These two Acts supplements the National Monuments Act through the Integrated Environmental Management procedure. Also, the Minerals Act (Act 50 of 1991) and the Minerals Amendment Act (Act 103 of 1993) require the Environmental

Management Programme (EMP) to indicate how the natural and cultural environment will be protected during the mining activity.

The main criticism of the National Monuments Act is that when the act was drafted there were no mechanisms specified to deal with material intended for protection. The other criticism is that the act was biased towards the conservation of colonial period structures to the detriment of pre-colonial archaeological resources. Furthermore, the act is not policed adequately. For example despite the fact that all sites older than 1652 are protected by legislation, in 1993 of the more than 4000 declared national monuments only 45 were archaeological sites (Deacon 1993).

Due to these shortcomings and the advent of the new Constitution, a new legislative framework was solely needed. The new Constitution gives concurrent powers to the National and Provincial government for the protection of cultural resources. At present, a new set of legislation is being debated in Parliament that will introduce some desperately needed changes to the National Monuments Act - the Heritage Resources Bill. The National Monuments Council will be replaced by the South African Heritage Agency (SAHA), with clearly set out rules and jurisdiction for both the National and Provincial governments. The cornerstone of the new legislative framework is integrated planning at local level and mandatory impact assessments for any new developments.

Summary

Although there are protected locales in the study area, this should not lull Archaeologists into a false sense of security. The threat to archaeological sites is real, and will most certainly increase in the future, resulting in even more pressure to an already threatened resource. Archaeologists and Cultural Resource managers therefore have to be alert and vigilant.

The National Monuments Council (NMC) as body responsible for the conservation of cultural resources has to ensure that the legislation is adhered to. In order to do that they have to have reliable and accurate information about the resource they are trying to conserve, in order to lend support to any legal and institutional framework that is in place. In addition to the NMC, other government agencies have a stake in the conservation of cultural resources. Government bodies like the National Parks Board, Provincial Authorities, and Local Authorities, all have a role to play to ensure that future generations have an opportunity to enjoy their cultural heritage in its best possible form. The proposed new legislation will attempt to spread responsibility and opportunity in the conservation of cultural resources so that both the National Government and Provincial Government have roles to play.

CHAPTER 5. NATURAL ENVIRONMENT

The purpose of this section is to review the environmental variables that were chosen in the study area in order to predict the location of archaeological sites in areas that have not been surveyed. In addition, this section is also necessary to provide a framework for assessing the distribution of archaeological resources for management purposes. For effective management, cultural resource managers need to know how many sites are located within a certain distance from the coastline, near rivers and estuaries, and at what altitude. This chapter provides an introduction to the study area, highlighting those aspects of the environment, which may be considered to have influenced the prehistoric settlement of the region. The majority of archaeological sites found in the area are under 10 000 years old - Later Stone Age - and since there is little evidence of major climatic changes during this time it is possible to use present ecosystems of the region in order to formulate models of prehistoric settlement patterns (Deacon & Lancaster 1988).

Topography, climate, and vegetation combine to form environmental constraints and possibilities of human adaptational systems in a landscape. In addition they interrelate with geology, soils, drainage in order to determine types, distribution, abundance of terrestrial and marine resources available for human exploitation. The available resources are in turn responsible for setting limits to human population growth and as to how populations arrange themselves upon the landscape. It is therefore necessary to present the account of the environment in order to provide both the 'scenery' against which the cultural drama took place and to ensure that any interpretation of the results of archaeological investigation is based on a clear understanding of the regulating factors imposed by the environment. In addition the account of the environment will be the basis for the predictive modelling exercise that is part of this project.

Coastline

A digitised 1:50 000 map of the coastline was obtained from the Department of Land Affairs - Surveys and Mapping. The map included all offshore islands including Robben Island and Dassen Island, and the coastline was classified into rocky and sandy shoreline, and also indicated where bays were located.

The coastline stretches 1308 kilometres from Table Bay in the south to Alexander Bay at the mouth of the Orange River (see Map 4 in Appendix C), and runs relatively linearly, given some shape by interspersed half-heart shaped bays and pocket bays (Jackelman & Moll 1989). From Milnerton Lagoon the coastline runs in a North-North-West direction until the Langebaan and the Vredenberg Peninsula where it cuts back in a easterly direction. North of that the coastline continues in its North-North-West direction all the way to the Orange River.

In total there are 67 bays covering a distance of 138 kilometres, the longest covering a distance of 16 kilometres. The major bays along the coast are Table Bay, the Saldanha Bay-Langebaan complex and St. Helena Bay (see Map 4 in Appendix C). St. Helena Bay and Table Bay are "half-heart" shaped bays that face north, which is an indication that the major swells and currents are from the south (Boucher & le Roux 1993). The most northerly major bay is Lamberts Bay, beyond which there are only small pocket bays. (Jackelman & Moll 1989).

The principal landforms found along the coastline include cliffs at Doringbaai, rocky platforms near Port Nolloth, bouldery beaches in Saldanha Bay, shelly beaches in Bok Bay, sandy beaches in Table Bay and estuaries like the Groen River estuary, to name a few. The norm along the west coast is eroding or retrograding beaches, except to the south of Yzerfontein and in St. Helena Bay where prograding or advancing coastline is found (Jackelman & Moll 1989).

Most of the coastal plain is covered with fixed or active dunes (Jackelman & Moll 1989). The extensive Tertiary to Recent dune fields extending in plumes in a north-easterly direction from existing or former river mouths are a feature of the South African west coast (Boucher & le Roux 1993). These dune fields are probably a result of sand blown off long sandy shores and are vital habitats for dune plant populations. Roughly there are three types of dunes found on the west coast. First, there are loose dunes that are sharply angular, continuously moving near the centres and sources of plumes. Secondly, there are less angular dunes which form a bumpy, undulating topography. Lastly, there are dunes that have been stable for the longest period with a rolling or gently undulating topography (Boucher & le Roux 1993).

An important effect of these sand dunes is how they influence and result in varied vegetation types due to their stability. The mobile sands driven by strong winds, salt spray from the sea, and intense radiation as a result of reflection from the sea and white sand all combine to affect plant communities along the coast. The dynamic nature of these sand dunes is such that plant communities are ephemeral and anything on the surface can disappear and reappear in a single storm event. Depending on the stability of the sand dunes archaeological sites can be exposed one day, and be completely covered the next day.

Offshore there are a number of islands that would have provided specific resources for people and would have influenced what happened on the coastline. These islands acted as breeding ground for various marine animals, such as seals, penguins and birds, which formed an important part in the diets of prehistoric people. The major islands are Robben Island, Dasseneiland, Marcus Island, Malgas Island, Skaapeiland, and Vondelingeiland around the Langebaan Peninsula, and Seal Islands around the Vredenburg Peninsula (see Map 4 in Appendix C). North of the Vredenburg Peninsula there is little or no visible activity offshore in terms of landmarks except for Bird Island at Lamberts Bay that is now joined to the mainland. In the past things might have been different to what it is today, as sea level changes would have created and flooded islands as the sea rose.

In general the subdivisions of the shoreline can be reduced to two, sandy beaches and rocky shoreline (Boucher & le Roux 1993) because of the ecological contrasts on these shores (Map 4 in Appendix C). There are rock platforms along most of the coast, which act as a substrate for a rich marine life. The stretches of rocky shoreline are where most of the species of animals of potential economic importance to people occur. There are seal, birds, crayfish, limpets and black mussels. On the other hand, areas with rocky shoreline have a stable substrata and shallow soils compared to the rest of the dune covered coastline or hinterland. In addition, these areas are often subjected to high winds and salt spray, which predictably leads to sparse vegetation because the moist, shallow pockets of soil are poor in nutrients and are frequently saturated with salt (Lubke et al 1997). The rocky shoreline covers a distance of 630.442 kilometres, which translate to 43 percent of the whole coastline. The rest - 813.231 kilometers - is a sandy shoreline.

Most of the long stretches of sandy beach are found between the Berg River and Verlorenvlei River; where there are also estuaries, cliffs, saltpans, mudflats, and wetlands (Jackelman & Moll 1989). The longest stretch of a sandy beach is roughly 50 kilometres long and is found between the Berg River mouth and Baboon Point at Elands Bay (Boucher & le Roux 1993). The exposed sandy shores support little or no exploitable animal life. Lack of shelter, and strong winds suggest that prehistoric people would have infrequently visited this type of shoreline.

The coastal strip around the Langebaan Peninsula and the Vredenburg Peninsula is the most varied section of the study area. The coastline is made up of mainly both north and south facing bays, interspersed by rocky shoreline, and occasional exposed sandy shores (Map 4 in Appendix C). These features and the offshore islands would have resulted in unique organisms and plants because of varying intertidal zones. As for the rest of the coastline, it is made up of long stretches of exposed sandy beaches broken by sheltered bays and isolated outcrops of rocky shore situated at the estuaries of rivers. This combination of rocky outcrops, sheltered bays and estuaries have an important bearing on settlement location and the subsistence behaviour of prehistoric people.

In terms of comfort and exploitation of resources, it would appear that areas which contain both stretches of rocky shoreline and sheltered sandy bays are ideal for occupation. On the other hand, rocky shoreline alone and areas of exposed sandy shoreline seem unsuitable for exploitation. Rocky shoreline appear to be the most suitable for the provision of food and one would expect occupation close to this type of shore to be favoured.

Climate

Climate has been described as the principal dynamic component and independent variable shaping both vegetation and soil. A clearer definition by Kendrew (1949) as a “long range pattern of weather” is precise because climate not only takes into consideration the prevailing weather conditions, but the dynamic and complicated variation occurring daily, monthly, seasonally and annually, and any variation from the norm. Climate controls rate of germination in plants, die-off/survival, biomass production mainly aided by temperature and precipitation, and reproductive capacity.

Climate, topography, edaphic and biotic concerns are four potential restraints on growth for land-based plant communities. The most important climatic factors in vegetation development, hence human development , are light, temperature, and moisture. These factors operate in combination to produce homogeneous environments essential to vegetation development.

The Cape weather system is governed by high pressure, sub-tropical anticyclones. In summer high pressure cells exist over the Atlantic and Indian Oceans, whilst there are low pressure cells over the subcontinent. These result in summer rainfall in the interior , but the western Cape is dry under the influence of the Atlantic high pressure zone. In winter the situation is reversed - the Atlantic high pressure moves in over the country resulting in dry weather an all areas except the western Cape

The coastline has a Mediterranean-type climate which is influenced mainly by the cold Benguela Current of the Atlantic, the circumpolar westerly winds and the subtropical high-pressure anti-cyclones (Boucher & le Roux 1993). Together with the earth's spin the Benguela Current deflects water away from the coastline and that results in the upwelling of deep, cold water rich in nutrients. As a result animals at a higher level in the trophic level, which are potential food for people, are found in abundance.

Before continuing with the discussion of climate, two marine phenomena found in the region will be discussed, because they exercise certain constraints and possibilities for human exploitation. First, is the presence of an oxygen-depleted sub-surface current off the Cape West Coast. Normally this current lies on the bottom, however occasionally it rises towards the surface and traps marine organisms against the shore retreating before it. This result in mass mortalities of animals such as white mussels (*Donax serra*) and crayfish (*Jasus lalandii*). All the animals driven inshore by this current would have been more easily exploited. The second phenomenon is locally known as the "red tide". The sea has large red patches caused by high concentration of the poisonous dinoflagellate, *Gonyaulax catenella*. This is caused by strong upwelling followed by calm conditions with a slight on-shore breeze resulting in warming-up of the cold upwelled water without it being dispersed by the normal off-shore currents. The "red tide" results in mass mortalities among filter-feeding animals such as black mussels and white mussels, which accumulate this toxin and are then eaten by animals higher in the food chain, which suffer the consequences. The occurrence of "red tide" probably was an important factor in the settlement decisions of prehistoric people.

Solar energy activates most vital biological processes like photosynthesis, photoperiodism, and phototropism. In addition the energy sources of all ecosystems are ultimately dependent on the quantity of incoming solar radiation. But solar energy is only biogeographically important when viewed with other climatic indices and in relation to the effect of varying topography. This is the case because altitude, sunshine duration, atmospheric moisture, cloud cover and dust cover all influence the amount of solar radiation at a particular location. There are both seasonal patterns of solar

radiation and effects of varying topography - daily incoming radiant flux densities are a function of slope, aspect and season. For example, in midsummer, radiation increases with the latitude for the north, north-east/north-west, east/west aspect, there is no variation for the south-east/south-west aspect, and for the south aspect solar radiation decreases with an increase in latitude (Schulze 1997).

According to Schulze (1997) temperature indirectly influences major regional vegetation formations through water availability - evapotranspiration. Within plant communities' temperature together with frost influences rates of growth, plant stature, seed germination, time of flowering and maturation of tissues. As a result what is important is a range of critical temperature indices such as summer maxima, winter minima and ranges rather than aggregate temperature values. The average daily temperature for Cape Town is 17.7 degrees Celsius, with a maximum of 22.3 and a minimum of 13.2, and a range of 9.2. The main influence on temperature on the Cape West coast is the effect of the cold Benguela Currents and the temperature irregularities induced by topographic variation. All along the coastline frost is rare and its occurrence is associated with cold snaps (Boucher & le Roux 1993). For the study area frost is not an influential factor because it is mainly a feature of the high-altitude interior areas of southern Africa (Schulze 1997).

Moisture availability to fauna and flora is considered to be the most important climate index (Walter 1972). The limitation absence of moisture restrict plant development, germination, growth and reproduction. Moisture acts as an energy exchanger and carrier of nutrient food supply. Moisture is essential for the physiological and chemical processes within the plant, in the exchange of energy and transport of nutrients (Schulze 1997). For the Cape West coast moisture is mainly derived from rainfall, and fog. Snow, as an ecological agent has minimal effect on the Cape West Coast. Although fog is often left out when talking about moisture, it is deemed to be beneficial and has profound effects on growth, development and distribution of plants. Along the Cape West Coast, radiation and advection fog is formed when surface water of the warm inshores mixes with upwelling cold water of the Benguela Current. In the afternoon the fog is blown inshore, where it is utilised by plants. In some areas, Nagel

(1962) estimate that fog precipitation can be as equivalent to 300 mm of rainfall per annum. As a result huge amounts of moisture not recorded conventionally may in fact be intercepted and utilised by plant cover.

The Cape West Coast has a winter rainfall regime with rainfall figures decreasing gradually further to the north. For example, the annual rainfall at Bloubergstrand is 378.7 mm and the annual rainfall figures for Port Nolloth are 39.7 mm. Map 5 (in Appendix C) shows the rainfall figures for January, July, and over a twelve month period. Fog frequency figures are the inverse of the rainfall figures. In a calendar year, on average Cape Town has 33 days of fog, Langebaan has 78 days, and Port Nolloth has roughly 146 days of fog. For both Cape Town and Langebaan most days with fog are during winter months. The trend is reversed for Port Nolloth, with fog occurring mainly during the summer. So, it would appear that although the annual rainfall figures are low along the Namaqualand coast, the moisture content is adequately supplemented by fog to make life possible in an otherwise arid environment.

Topography

The impact of climate on the environment is a function of a number of factors including topography. For example, the daily incoming radiant flux densities on a sloping terrain are a function of slope and aspect, which are both a function of topography, and season. In midsummer, radiation increases with latitude for north, north-east/north-west and east/west aspects. That is not the case for south-east/south-west aspects and it is only on south aspect is a decrease of radiation evident with increasing latitude. On north aspect the steeper slopes receive more energy. In midwinter the influence of latitude is most noticeable. The greatest differences are found in east/west aspect. Once again on the north aspect the steeper slopes receive more radiation.

Elevation

The topographic data for the study area is represented by a proxy variable, the Digital Elevation Model (DEM). A DEM is a raster data model representing the continuously varying features of topography. A raster image comprises a collection of grid cells rather like a scanned map or picture. Thus, a DEM is a data set representing the surface of the earth. A DEM is a more useful tool for representing the surface of the earth than contour lines because, contour lines represent the surface values of the earth as distinct lines that join points of similar values. On the other hand a DEM represent the surface of the earth as a continuous surface, which is a more realistic presentation. The Digital Elevation Model for the study area is given in Map 6 (in Appendix C). The DEM for the study area was purchased from Surveys and Mapping, a cartographic section of the Department of Land Affairs. The size of the pixels for the DEM are 400 meters by 400 meters.

The minimum elevation value for the study area is 0 meters above sea level and the maximum elevation value is 563 meters above sea level. What is important are not only the absolute elevation values, but also the topographical variation. For example a landscape can be a gradual incline with elevation values from 0 to 500 meters above sea level over a 20 kilometre distance. Another landscape can have elevation values that only go as high as 150 meters above sea level, but over a much shorter distance, *i.e.* 1 kilometre. The latter landscape has more topographical variability that is likely to result in the presence of cliffs, caves, and overhangs. Figures 5.1, 5.2, 5.3 5.4 show the cross section of the study area at Yzerfontein, Elandsbay, Kleinzee and Cliff Point just north of Port Nolloth respectively. These profile clearly show that the cross section for Darling, Vredenburg and Elandsbay are different from that of Namaqualand. The Namaqualand profile gradually increase over the 20 kilometre distance, whilst the other profile vary with peaks and troughs throughout the 20 kilometre distance.

The present topography is a result of a number of factors, including geology, and run-off rate due to precipitation. Moving along the study area from the south northwards,

the first area of topographical variation is the region around Darling with Dassenberg, Contreberg, and Kapokberg. Figure 5.1 shows the elevation profile for the region around Yzerfontein. North of Darling the topography is fairly flat until the Saldahna and the Vredenberg Peninsula. This is due to the Granite outcrops found in both regions. Nevertheless, the topographic variation provided by granite outcrops is moderate when compared with variation found in the area between the Berg River and the Olifants River.

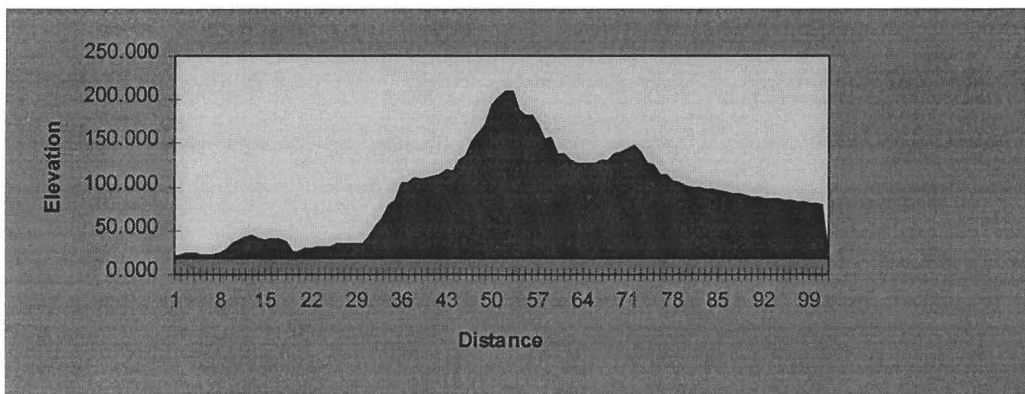


Figure 5.1 Topographic Profile Through Yzerfontein.

The area between the Berg River and the Olifants River is a region of extensive topographical variation. The Table Mountain Supergroup geology is extended all the way to the coast resulting to extreme topographic variation. At Baboon Point, over a distance of less than 500 meters the topography changes from being flat to cliffs and caves (Figure 5.2). This topography would have been attractive to prehistoric people because of the shelter it provided from wind. A cross-section of the study area reveals a landscape made up of hills and valleys, and cliffs (see Figure 5.2).

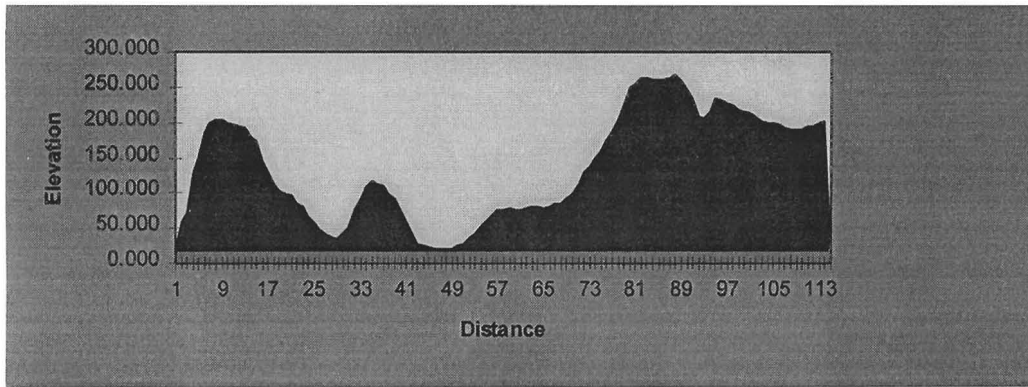


Figure 5.2 Topographic Profile Through Baboon Point.

North of the Olifants River the trend of gradual increase of elevation values as one moves away from the coast continues. The only difference being that there is no extreme topographic variation. The scenario is that of a landscape that gradually becomes steep at a fairly uniform rate (Figure 5.3 & 5.4). There are no hills, cliffs, or any sudden changes in the landscape, as a result the landscape provides little or no protection from the elements. There are hardly any caves, rocky outcrops to provide any shelter.

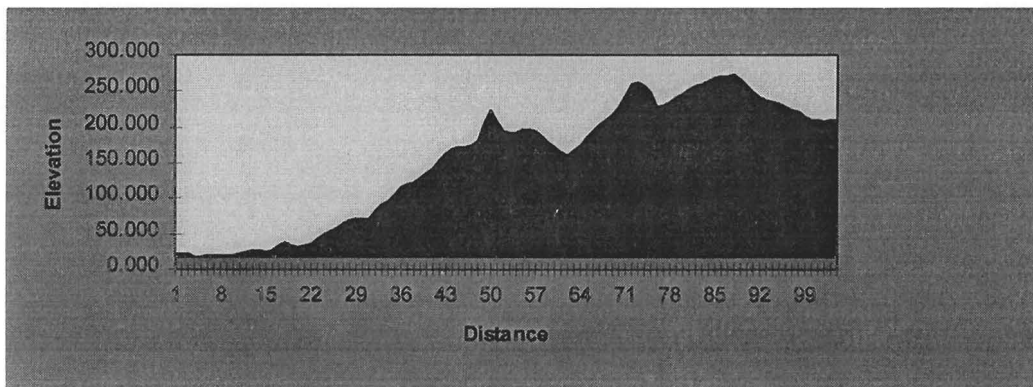


Figure 5.3 Topographic Profile Through Kleinzee.

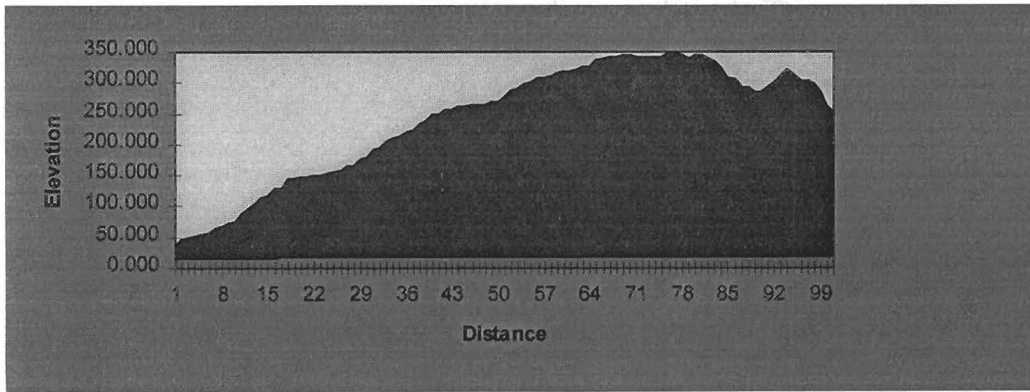


Figure 5.4 Topographic Profile Through Cliff Point.

The overall variation of elevation in the study area is given in the histogram below, Figure 5.5. According to Figure 5.5 most of the study area has elevation values that are between 40 metres above sea level and 186 metres above sea level.

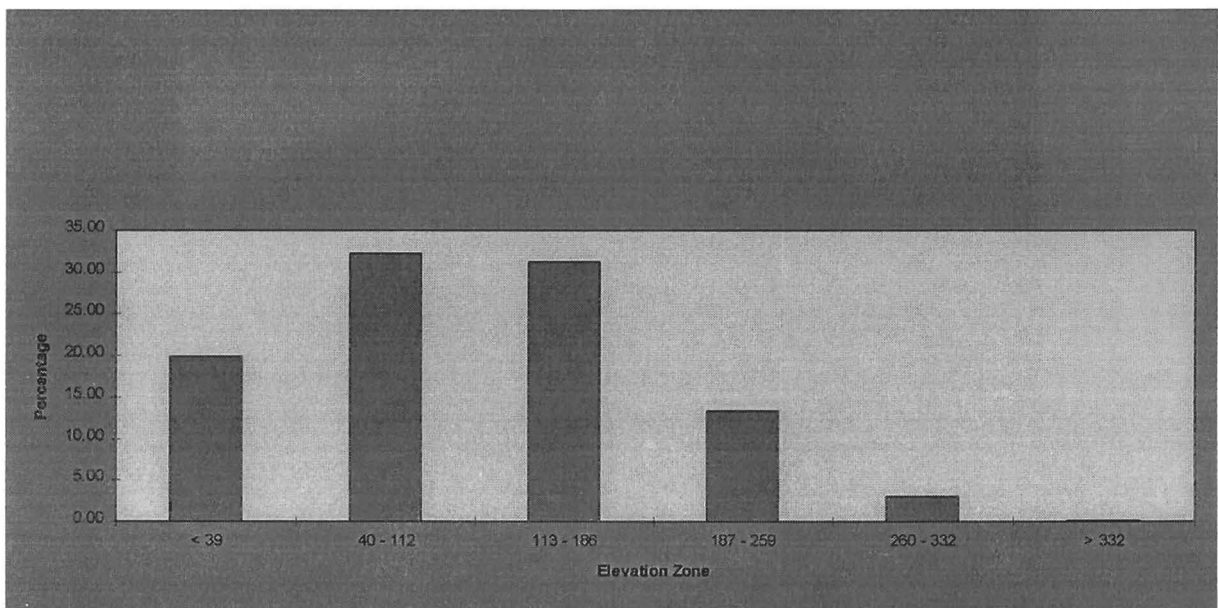


Figure 5.5 Histogram of Elevation Values in the Study Area.

An additional variable that can be derived from the Digital Elevation Model is Hillshade. Hillshade is a hypothetical illumination of a surface as part of an analysis step or for graphical display. For analysis, Compute Hillshade can be used to

determine the length of time and intensity of the sun in a given location. For a graphical display, Compute Hillshade can greatly enhance the relief of a surface when the output is used as the brightness theme for the display of another grid theme.

Various features in the input grid theme can be accentuated, and different effects achieved, by altering the azimuth and altitude parameters. The azimuth is expressed in positive degrees from 0 to 360, measured clockwise from north. The altitude is expressed in positive degrees, with 0 degrees at the horizon and 90 degrees directly overhead.

Cumulative viewshed analysis studies are made possible by knowing the aspect and slope of the landscape being analysed. This analysis attempt to determine the inter-visibility between sites. Common sense posits that people will choose a shelter that is protected from wind, and that has optimum exposure to the sun. With visibility people would not necessarily try to optimise all the time. One would expect people to attempt to minimise visibility for archaeological sites with symbolic or ritualistic importance. What is likely to happen is that prehistoric people would choose a site that is not easy to locate but the view from the site is optimised.

Slope

Given an elevation model (an initial surface), the surface can be used to derive new representations of that surface, slope. Slope is defined as the rate of maximum change in *z-values* from each cell of the DEM. Slope is expressed as percent slope or degree - in this project it is expressed in degrees. This function of a DEM measures the steepness and has values that fall between 0° and 90°. A value of 0° indicate a vertical surface, and a flat surface is indicated by a value of 90°. Map 7 (in Appendix C) illustrate the slope of the study area and is derived from the DEM. The histogram in Figure 5.6 show the spread of slope values for the study area. The mean value for slope in the study area is 59.083° with a standard deviation of 20.307°.

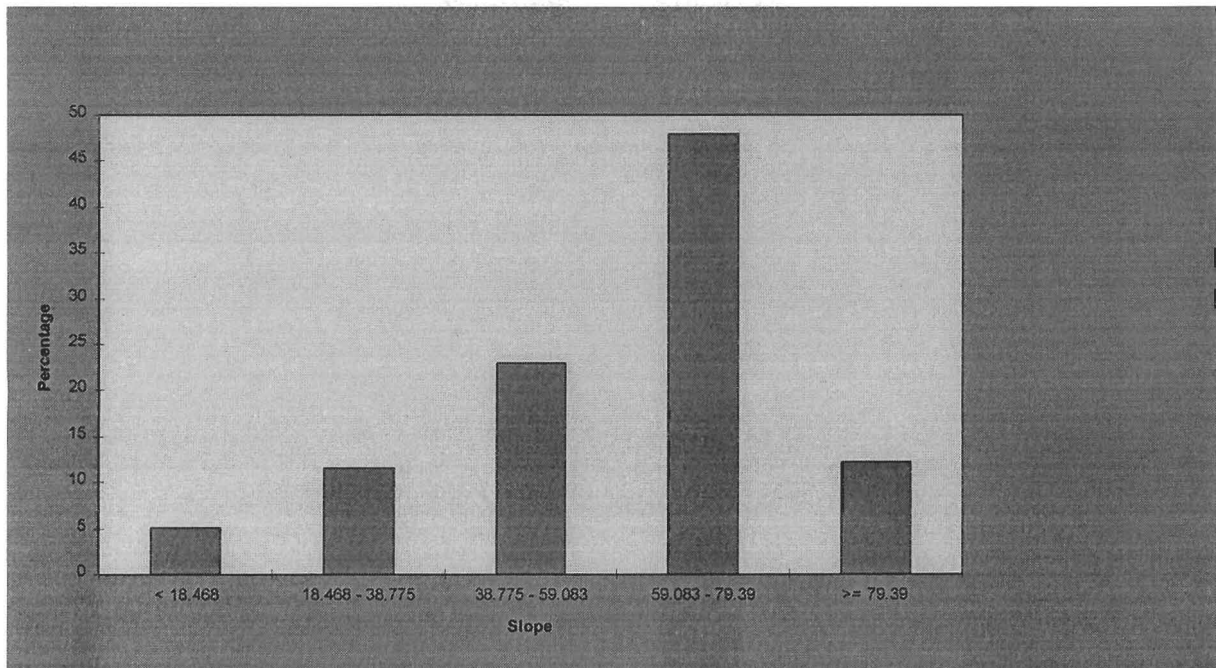


Figure 5.6 Histogram of the Slope Variable.

According to Figure 5.6 the study area is relatively flat. Most of the slope indices are between 59.083° and 79.39° . There are some areas that were fairly steep, which attest to the presence of cliffs and steep inclines in the study area.

Aspect

Aspect identifies the direction of maximum rate of change in *z-value* from each cell of the DEM. Aspect measures the orientation of slopes - down-slope direction of slope - which influences shelter from winds, exposure to sunlight and visibility in a particular direction (Tapia and Tapia-Recillas 1996). This particular function of a DEM has values that fall between -1 degrees and 360 degrees. For example a flat surface or slope has a value of -1 degrees, and a north facing slope has the values 0 - 22.5 degrees and 337.5 - 360 degrees. The histogram showing the spread of aspect values for the study area is given in Figure 5.7. Map 8 (in Appendix C) illustrate the aspect of the study area derived from the DEM - north, east, west and south facing slopes respectively. For the study area, the extent of north and south facing slopes is more or less the same.

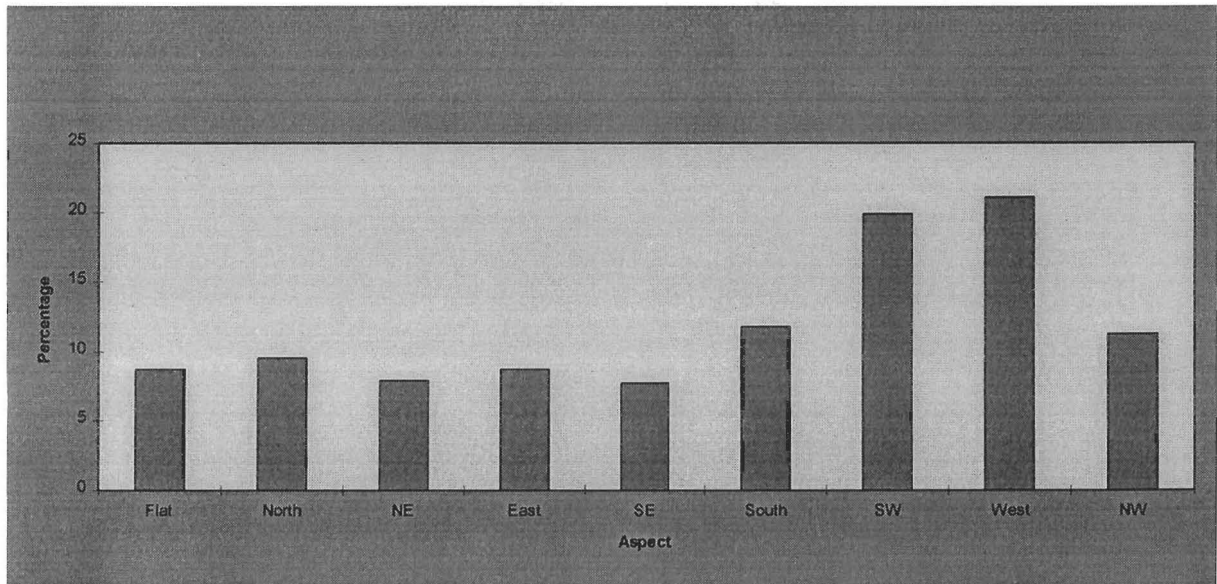


Figure 5.7 Histogram of the Aspect Variable.

There is a fairly uniform spread of slope directions in the study area (see Figure 5.7). The only exception are the south-west and the west facing slopes, which are dominant.

Hydrology

The hydrological datasets were extrapolated from the 1:50 000 topographical and cadastral series available from the Surveyor-General. Most of these cadastral boundaries were digitised by the Surveyor-General's office from "Noting Sheets" which range in scale from 1:50 000 to 1:6 250. A digitising error of 1 mm will therefore represent a ground error of between 50 metres and 6 metres at these scales respectively. However it is known that larger errors occur in some areas possibly due to errors on the original Noting Sheets. It is important to note that certain boundaries of properties, notably rivers and the coastal high water mark, are unsurveyed and are generally only based on rough sketchmaps. Such unsurveyed boundaries therefore often bear little relation to the ground position of these features. The position of rivers and the coastline may also shift over time to a greater or lesser extent.

There are three subdivisions of hydrological features and they are perennial rivers, estuaries, and dry river catchments. The rivers were an important source of freshwater for prehistoric people. In addition the aquatic fauna present in the rivers would have been an important part of the diet. Today, there are roughly 25 species of indigenous freshwater fish found in river systems in the study area (Robertshaw 1979). According to Parkington (1976), the freshwater fish present in the rivers provided people with a resource to either eat on the spot or to be dried for later use. Freshwater fish like *Labeo seeberi* (Clanwilliam sandfish), *Barbus capensis* (Clanwilliam yellowfish) and *Barbus serra* (sawfin) were to be found in the Olifants River, *Labeo capensis* (mudfish) in the Orange River, and *Barbis andrewi* (witvis), and *Sandelia capensis* (Cape kurpur) in the Berg River.

The major perennial rivers located in the study area are the Berg River System, the Olifants River System, and the Orange River System (Map 9 in Appendix C). The Berg River and its tributaries navigate its course in the steep mountains of the Cape Fold Belt. This is an area of high rainfall and slow release of water by sandstone. The Berg River system winds northwards and then westwards across the Coastal Foreland to the Atlantic Ocean. As expected the maximum flow for the Berg River occurs in winter and because of the powerful scouring effect during the wet season there is little submerged vegetation. On the other hand because the Berg River flows all the time, the river system has a wide range of faunal communities that prehistoric people would have exploited. North of the Berg River there is the Olifants River system. The Olifants River system also begins in the Cape Folded Belt. It then flows to the Atlantic and once it reaches the Coastal Foreland it is joined by most of its major tributaries. An estuarine environment forms where the Olifants River breaks through the barrier of the coastal dunes at Papendorp.

The Orange River system is different from both the Berg River system and the Oliphant River system in the sense that the source of the river system is in the high mountains of Lesotho - a summer rainfall area. From the source the Orange River flows for over 1600 kilometres through a summer rainfall area. Along its course the Orange River is joined by two of its major tributaries, the Vaal River and the

Namibian Great Fish River. The Orange River then emerges into the coastal plain and meanders to the Atlantic Ocean.

The minor perennial rivers in the study area are the perennial rivers are (see Map 9 in Appendix C) the Groen River, Mud River, Sout River, Dieprivier, Papkuisrivier, Verlorenrivier near Elands Bay, Langvleiriver near Lamberts Bay, Jakkalsrivier, Spoegrivier, and Swartlintjiesrivier. Just like the three major river system - Berg River, Olifants River and Orange River, these perennial rivers played an important role in settlement decision and resource availability for prehistoric people. The vleis associated with these have slightly brackish water and the salinity of the water varies from being almost fresh in winter to brackish in summer. The vleis had a number of possible resources for prehistoric people. Prehistoric people could have exploited indigenous fish like haarder (*Liza ramada*) and white steenbras (*Lithognathus lithognathus*). Cormorants (*Phalacrocoracidae*) and white pelicans (*Pelecanus onocrotalus*) are common (Robertshaw 1979).

As it has been mentioned earlier in the study area there are also seasonal rivers and streams. The availability of water was only limited during the rainfall season, which would make settlement near these rivers possible. As a result a seemingly resource inhospitable area could be hospitable during the rainfall season. Map 10 (in Appendix C) show seasonal streams and rivers that are found in the study area. These non-perennial seasonal streams form the bulk of dynamic water bodies in the study, but their influence on human population is likely to be minimal. Along the coast seasonal streams are more common in the northern area than the southern area. This is mainly due to low rainfall figures and absence of sandstone where the rivers begin, which is an excellent aquifer. As a result these seasonal streams are likely to contain little in terms of aquatic exploitable resources like fish.

Estuaries come in all shapes and sizes and go by many different names : marshes, swamps, lagoons, harbors, inlets, sounds or sloughs, depending on where you live. They are the meeting place of the river and the sea, are tidally-influenced and are protected from the full force of ocean waves, winds and storms by the reefs, barrier islands, or fingers of land, mud or sand that define an estuary's seaward boundary. The

term estuary as used in this section is defined in a broad sense to include inlets of the sea, lakes, and lagoons. Nevertheless it might be necessary to give a brief description for each of these water bodies. First, an estuary is that part of a river system where there is enough variation in salinity (Day 1952), because of its close proximity to the sea. Secondly, a lagoon is a stretch of water separated from the sea by a low sandbank. Thirdly, a river inlet refers to the sheltered inlet of the sea which, is neither a lagoon nor an estuary. Last, a salt pan refers to a body of water with variable salinity due to the evaporation of shallow water. There are two main classes of pans, those near the coast and those that are inland. Coastal pans are usually at a low level, frequently lagoons that have been cut off from the sea by a belt of sanddunes, hence they tend to be elongated (Du Toit 1954). They are saline but sometime fresh water pans occur in close proximity. Inland pans are often a result of a number of factors including the level of water-table, soil type, rate of evaporation, and the salt content of the soil. For example if a depression on the landscape has a high water-table, a clayey soil, low rate of evaporation and soil with a high salt content, the chances are with time area will become a pan.

How important are they?. Estuaries are some of the most important and complex links in the Earth's entire ecosystem. What do they do?

- Nurseries of the sea --Estuaries are nursery grounds for two-third's of the fish and shellfish we eat and provide habitat for tens of thousands of birds and other wildlife.
- Productivity -- A healthy, untended estuary produces from four to ten times the weight of organic matter produced by a cultivated corn field of the same size.
- Water filtration -- Estuaries provide important water filtration services. Water draining from the land into the river carries a load of sediments and nutrients. As the water flows through salt marsh peat and the dense mesh of marsh grass blades, much of the sediment and nutrient load is filtered out, creating cleaner and clearer water.
- Flood control -- Porous, resilient salt marsh soils and grasses absorb flood waters and dissipate storm surges (Environmental News Network 1998).

How have we treated them? Badly. Long considered junk land, they've been dredged, filled, built on and generally mistreated. They continue to be threatened by urban growth and development, nutrient over-enrichment and habitat loss.

Estuaries played an important role in the lives of prehistoric people. They were a source of water in an otherwise arid environment, they served as an aggregation point for wildlife and other exploitable aquatic species. Plant foods appear to be rare, but many species of marine fishes enter and live in estuaries. For example white steenbras (*Lithognathus lithognathus*) and white stumpnose (*Rhabdosargus globiceps*) commonly enter estuaries. These estuaries also provide a rich habitat for a variety of bird species. Birds such as herons (*Ardeidae*), spoonbills (*Platalea alba*), flamingos (*Phoenicopteridae*), and gulls (*Laridae*) are found commonly in many estuaries. Map 11 (in Appendix C) show some of the estuaries found in the study area. They vary in size and the salinity of water depending on the amount of rainfall they receive, rate of evaporation, presence or absence of sand bank blocking the sea.

Geology

The Geology data set was acquired from the Centre for Interactive Graphical Computing (CIGC) of the Department of Geological Sciences, University of Cape Town. The CIGC map subdivide the study area into 9 geological formations, they are, Namaqualand Metamorphic Province, Gariiep Complex, Vanrhysdorp Group, Cape Supergroup, Malmesbury Complex, Klipheuwel Formation, Tertiary Formation, Quaternary Formation, and Intrusive Rocks like the Cape Granite Suite, Little Namaqualand Suite, Hoogoor Suite, Gladkop Suite, and others (Map 12 in Appendix C). The geological formations are outlined in Table 5.1.

Geology	% Part of the Study Area
Namaqualand Metamorphic Province	0.78
Gariiep Complex	3.27
Vanrhynsdorp Group	0.3
Cape Supergroup	4.06
Malmesbury Group	2.9
Klipheuwel Formation	0.19
Tertiary Formation	4.5
Quaternary Formation	71.2
Intrusive Rocks	8.57

Table 5.1 Geological Breakdown of the Study Area.

The geological profile of a landscape consists of sedimentary, extrusive, intrusive and metamorphic rocks, and its history is often expressed by the physiographical details of the landscape. The study area is made up of two physiographic zones, the Coastal Belt and the Western Plateau slopes. The Coastal Belt is a result of a phase of marine erosion at altitude of less than 300 m above sea level. From Cape Town, the Coastal belt continues towards the north where it has been eroded into the rocks of the Malmesbury Group, the Cape Granite Suite and the Cape Supergroup, and ends just north of Lamberts Bay. The Coastal Belt is covered by Tertiary and Quaternary Rocks and in part by sands of Recent origin (Du Toit 1954).

The second physiographic zone in the study area, Western Plateau Slopes, extend northwards along the coast from where the Coastal Belt zones ends. This region rises from sea-level to an altitude of 300 m at the base of the escarpment. It is covered by the remnants of Late Tertiary and Quaternary marine formations and Recent sands. In the south, the Western Plateau Slopes are underlain by the Vanrhynsdorp and Nama Group, and in the north by rocks of the Okiep group and Gariiep Complex.

In both physiographic regions, granite and gneiss intrusions are common. In the Coastal Belt the intrusions are solely by the Cape Granite Suite and the Klein Kogelfontein Complex. In the Western Plateau Slopes the intrusions are by the Hoogoor Suite, Gladkop Suite, Spektakel Suite, Little Namaqualand Suite, and Biesiesfontein Granite.

The Namaqualand Metamorphic Province geology is an assemblage of metasedimentary and metavolcanic rocks. It is divided into 6 groups of which only one falls in the study area, the Okiep Group. The Okiep Group is further divided into 4 subgroups: Bitterfontein, Garies, Khurisberg and The Een Riet and Aardvark, and forms about 0.78 percent of the study area. Found in the Namaqualand coastline, north of the Olifants River all the way to just north of Swartlintjiesrivier. The Okiep Group is mainly made up of quartzite, gneiss and schist.

The Gariiep Complex is so named after an indigenous word for the Orange river and refers to volcanic and sedimentary rocks in the central and western parts of the Richtersveld. The Gariiep Complex stretches from Kleinzee in the south to Luderitz in the north and is divided into 6 formations of which 4 are in the study area They are the Stinkfontein Formation, Holgat Suite, Grootderm Suite and Oranjemund Suite. The Gariiep System is deposited in geosyncline on gently folded Kheis rocks prior to the period of intense folding and granitization to which the latter was subjected. Common rocks include quartzite, limestone, schist, and dolomite. the Holgate Suite - which is part of the Gariiep System - is thought to underlie most of the sand-covered coastal plain of the north-west Namaqualand (Visser 1989). It consists of a great thickness of sediments which show considerable lateral variation and include schists, quartzites and graywackes with minor hornfels, limestones, conglomerate and tillite. The beds have suffered mild deformation although a number of faults have been postulated to explain some of the discontinuities of the outcrop. Furthermore, thermal metamorphism has converted graywackes into recrystallized products resembling gneiss. The Stinkfontein Formation is composed of conglomerate and coarse sandstone, and is responsible for the high mountain ranges in the central Richtersveld.

The Vanrhynsdorp Group is exposed over a fairly extensive area in the environs of Vanrhynsdorp. This geological group is further classified into four formations, of which only the Gifberg Formation and Knersvlakte Formation fall within the study area. The Gifberg Formation is composed of limestone and marble, and is found near the Olifants River - on either side of the river mouth and along the river course. The Knersvlakte Formation is composed mainly of mudstone and shale, with interbeds of sandstone. This formation occupies a shallow basin which is topographically fairly even and rather monotonous, near the Groenrivier (Visser 1989).

The Cape Supergroup is found in the south-western and southern parts of the Cape, and is classified into three groups: Table Mountain Group - thick unfossiliferous grits and sandstones with scattered pebbles, Bokkeveld Group - shales and flagstones, and the Witteberg Group - quartzites and subordinate shale. The Table Mountain Group which forms part of the study area is further divided into 3 formations: Graafwater Sandstone Formation, Piekenierskloof Formation and Peninsula Formation. The Cape Supergroup was involved in the intense folding which affected the southern extremity of the continent. The Table Mountain Group that is part of the study area rests upon tilted Malmesbury beds or their intrusive granites. It is composed wholly of sandstone - whitish in colour and moderately coarse in grain, rather hard. The Table Mountain Group breaks down to form a sandy whitish or grey porous sandy soil, dotted with tiny white quartz grains and small pebbles. The soils that evolved from it are poor supporting mainly grasses and reeds, and protea or sugar-bush are the principal trees. Hence, there are few farms under cultivation on the sandstone areas. The massive nature of the Table Mountain Group is responsible for the majority of the mountain ranges shutting off the Karoo from the sea and determined much of the present coastline. The most northerly occurrence of the Table Mountain Group builds the table-topped Bokkeveld Mountain north-east of Van Rhynsdorp (Visser 1989).

The Malmesbury Group beds consist mainly of sedimentary rocks deposited in a geosyncline that are folded along axes striking north-west. This group is composed of slates, phyllites, argillaceous quartzites and limestones and basic igneous rocks and chert (Visser 1989). The Malmesbury is folded with high dip, intruded by granitic

rocks and uncomfortably overlain by the Palaeozoic Table Mountain series. The Malmesbury beds are strongly folded, and the strike is North-North-West. Constant metamorphism of the quartzites by the Table Mountain series has resulted in spotted hornfels. No true idea of the thickness of the succession has been obtained nor is its base known, but it is accepted that the thickness is considerable. The metamorphism of rocks is of a low grade, outcrops are poor, and Cape Granite Suite is intrusive.

The Klipheuwel Formation occurs fairly widespread in the western part of the Cape. This formation is composed of conglomerate, coarse-grained, reddish sandstone and shale. The most northerly occurrence of the Klipheuwel Formation is Elands Bay, and its most southerly occurrence is on the upper reaches of Dieprivier. The presence of Klipheuwel Formation in the study area is minimal and it only forms 2.9 percent of the region.

Tertiary Formations are superficial deposits which consist of sand, gravel, soft sandstone and limestone. Marine deposits which contain fossils are found along the coast. The Tertiary Formations that are found in the study area are the Bredasdorp Group and the Kalahari Group. The Bredasdorp Group and its correlatives is composed of marine phosphatic sandstone and phosphorite, and is found in the environs of Saldanha Bay - at Hoedjiespunt it rests on the floor of Cape Granite and is covered by marine shell limestone.

Quaternary Formations includes river-terrace gravel, vlei deposits, deposits around springs and in caves, surface limestone, calcified dune sand, silcrete, alluvium and surface sand. This is by far the most common formation in the study area, coastal sands and terrace gravels are found from Milnerton up to the Orange River. Quaternary Formations forms 71.2 percent of the study area and their distribution along the study area is interrupted in the south by the Malmesbury Group, Cape Granite and Tertiary Formations around Saldanha. North of St Helena the major interruption is by the Cape Supergroup in Elands Bay (Visser 1989).

Intrusive Rocks, are rocks composed of both acid and basic and ultrabasic rocks found in the southern Coastal Belts. First there is Klein Kogelfontein Complex which is found in the southern part of the Namaqualand Metamorphic Province. The Klein Kogelfontein Complex is an intrusive to the rocks belonging to the Little Namaqualand Suite. Secondly, there is the Cape Granite Suite located in the western and southern part of the Cape Province. The Cape Granites have a strata elongated in NW-SE direction following the foldings of the Malmesbury Series. The strata experienced low-grade metamorphism which indicate that intrusion must have taken place towards the end of the compressive period. Cape Granite Suite geology is composed of Granite and Biotite Granite. The largest Cape Granite strata is a lobed body about 50 kilometres in length forming hills among which the town of Malmesbury is situated. Another significant strata is the one extending from St. Helena Bay - 20 kilometres by 5 kilometres (Visser 1989).

During data collection, I was unable to find a soil map with an appropriate scale that covers the whole study area. The nature of the project is such that it is possible to add this variable at a later stage. Despite the inability to acquire a soil map, the geological map is a reasonable proxy variable. According to Du Toit (1954) geological formation provides the raw material from which the soil becomes evolved under the superimposed influences of position, climate and organic life. Factors that can influence soil evolution are geology, climate, vegetation, salts - chlorides and sulphates, ants, earthworms and rodents, and micro-organisms. In addition slope also influences soil evolution. On 10 degree slopes, sheet-flood erosion commonly exceeds soil renewal, hence the soils will be shallow and under-developed. Moisture content also influences soil evolution, in arid regions, mechanical disintegration predominates over chemical, therefore soils are more dependent on geological formation.

Vegetation

Climate, soils, and topography play an important role in determining the character of vegetation. The Cape west coast has 4 physiographic zones, namely the Sandveld,

Coastal Foreland, mountains of Cape Fold Belt, and the Karoo. These physiographic zones have different rainfall and geology, which result in different vegetation and therefore provide different set of resources. These boundaries are likely to have been in place in the last 10 000 years except for disturbance brought about by the introduction of agriculture which resulted in an increase in fire frequency and grazing. Our knowledge of vegetation therefore will afford the ability to reconstruct likely prehistoric faunal communities at least for the recent Holocene past (Deacon & Lancaster 1988).

The Vegetation map used in this project was compiled by the National Botanical Institute and the South African Association of Botanists. The map is not based on Acocks' (1980) vegetation map, but has been formulated through continuous updating in order to lessen the gap between a biome map and Acocks' map. The map has a scale of 1:800 000 and was produced from original maps which varied in scale from 1:50 000 and 1:500 000.

Plants, terrestrial and marine animals probably constituted a major part of the diet. Therefore occupation would have been geared to the peak availability of most abundant foods. Vegetation to a large extent controls the distribution, abundance and availability of terrestrial resources, with climate and topography playing minor roles. Winter and early spring are the major growing seasons of the Cape coastal vegetation. Corm-bearing and fruit-bearing trees tend to flower in the spring months of August to October. In addition, corms of Iridaceae are impalatable and shrinking between the moment of new growth in early to mid-winter and flowering in spring (Parkington 1976). Therefore, "fruits and corms seem to exhibit peak and troughs - in availability and palability - which coincide roughly with summer and winter months respectively" (Parkington 1976:43). The area has an abundance of seasonal fruits and berries. These include the Hottentots fig (*Carpobrotus edulis*), sour fig (*Carpobrotus acinaciformis*) and skilpadbessie (*Nylandtia spinosa*) (Silberbauer 1974).

South African vegetation is rich in species with the vast majority of which are endemic to the region (Cowling & Hilton-Taylor 1997). These species form more than

70 vegetation units that in turn form the seven floristically distinct biomes (Acocks 1975; Rutherford 1978). These biomes, of which three form part of the study area, are broad ecological units that represents major life zones extending over large natural areas. The biomes that form part of the study area are Fynbos, Succulent Karoo and Nama-Karoo.

Nested within the seven distinct floristic biomes are southern Africa’s 70 ‘veld types’ according to Acocks (1975). Veld types are “a unit of vegetation whose range of variation is small enough to permit the whole of it to have the same farming potentialities” (Acocks 1975). Six ‘veld types’ fall within the study area, and they are Coastal Macchia, Coastal Renosterbosveld, Macchia(fynbos), Namaqualand Broken Veld, Succulent Karoo, and Strandveld of West Coast (see Map 13 in Appendix C & Table 5.2).

Vegetation Type	% Part of the Study Area
Coastal Renosterveld	5.9
Succulent Karoo	33.8
Strandveld of the West Coast	42.1
Coastal Macchia	14.1
Namaqualand	0.2
Macchia (fynbos)	0.04

Table 5.2 Different Vegetation Types in the Study Area.

The Coastal Macchia occurs on leached acid sands accumulated *in situ* from the weathering of granites and sandstones, leached maritime sands, or wind blown accumulations of sand from rivers and estuaries (Boucher 1983). Coastal Macchia lacks the dense thorniness and semi-succulence of shrubs found in heavier soils. The veld type is found in areas with rainfall that ranges from 300 - 500 mm per annum. This veld type extends from Verlorenvlei River to False Bay on limestone and sandy

substrates. The altitude ranges from 0 metres above the sea level to 300 metres above sea level (Acocks 1975). Its diagnostic growth forms are restioid herbs, ericoid and proteoid shrubs and it exhibits a complex seasonality and is adapted to a fire regime (Boucher & le Roux 1993). Coastal Macchia is dominated by typical Cape elements, for example proteaceae, restionaceae, ericoid-leaved shrubs, but no ericaceae. Furthermore three of the five endemic Cape families, that is *Bruniaceae*, *Penaeceae* and *Stilbaceae*, are found in this Veld type. Some components of the coastal fynbos are out of phase with the environment because they grow when it is dry during the summer period. Coastal Macchia is anatomically adapted to use water efficiently because it grows in an area where the rainfall figures are between 100 - 700 mm. per annum. It has small reduced leaves, low proportion of succulents and the perennial herbaceous flora is largely hard and stiff with reduced leaves and photosynthetic stems. The latter feature is a possible adaptation to low nutrient status of the substrate where coastal fynbos is found (Boucher 1983).

Macchia also known as mountain fynbos is found on hard quartzitic rocks belonging to the Table Mountain Group. This Veld type is one of the six floral kingdoms and is characterised by very high species diversity. There are approximately 6000 known species, a sign indicating that the vegetation is old (Acocks 1975). Mountain fynbos is adapted to periodic fires which are followed by a spectacular display of flowers by plants with underground bulbs, corms and rhizomes (Cowling *et al.* 1997). In this Veld type trees are rare and are only found in valleys and ravines where the soil is deeper. Mountain fynbos is also poor in grasses for grazing animals and edible geophytes whose corms were sought by prehistoric people. It is found in areas with at least 250 mm of rainfall per annum. Mountain fynbos is composed of ericoid shrubs, which are low evergreen shrubs with hard, narrow, rolled leaves. Restioid herbs which are reed like, tufted evergreen plants with nearly leafless stems are present (Acocks 1975), as well as proteoid shrubs, which are medium to tall shrubs with large, leathery and hairy leaves.

The Coastal Renosterveld is a low to mid-high, open to mid-dense shrubland often with an open grassy understory. It is found on shales and granites in the 250 - 550 mm

per annum rainfall zone. It occurs in two fairly distinct blocks, in the undulating country of the west coastal plain (Acocks 1975). The species diversity of this Veld type is lower than that of fynbos and has the renosterbos as the dominant species (Boucher 1983). Like the fynbos it does contain ericoids, proteoids, although they are rare. There are annual herbs and grasses are more common. The Coastal Renosterveld is not true Cape heathland vegetation because of the lack or rarity of the ericoid component. It is more akin to the Californian Coastal Sage because it is also a product of a disturbed environment (Rutherford 1978), which is shown by the dominance by a few species with pioneering abilities. The Renosterveld generally lacks fynbos characteristics - restoids and proteoids, although it is found throughout the fynbos biome on lower mountain slopes, interior valleys and coastal forelands (Cowling *et al.* 1997).

The West Coast Strandveld is found along almost the entire South African west coast except near the Olifants River where Succulent Karoo is found. This is a Mediterranean-type shrubland vegetation (Boucher & le Roux 1993) found in regions which receive 50 - 300 mm of rain mainly in winter (Acocks 1975). There are two variations of this Veld type, a dense, dwarf, semi-succulent scrub and the Strandveld proper, an open, semi-succulent scrub of fynbos form (Acocks 1975). The West Coast Strandveld is found on calcareous dune sands, calcretes, limestones, weathered granites and shales. This Veld type is dominated by fairly continuous canopy of sclerophyllous, nanophyllous to microphyllous shrubs. The West Coast Strandveld is very variable, for example the sandy littoral supports prostrate, spreading succulent chamaephytes and the isolated shelter between dunes supports tall broad-leaved sclerophyllous scrub up to 3.5 metres (Boucher 1983). Succulents are prominent, and in Namaqualand this vegetation has a more open canopy than in the western Cape and it is generally shorter. The West Coast Strandveld is a typical Mediterranean-type climate shrubland vegetation adapted to a fire regime, it grows in winter when it is wet and after a fire, and dormant when it is dry. The vegetation type is restricted to deep, coarse aeolian sediments of the winter rainfall west coast (Milton *et al.* 1997)

The Succulent Karoo is a sparse shrubland, with a high density of succulents, geophytes, and therophytes. On sand, the Succulent Karoo is a taller mixed shrubland with grasses. It is often present in the Ecca and Dwyka shales of the Karoo system which have fine-grained and leached soils (Milton et al 1997). This is a hot, arid area with low rainfall regime, between 50 - 200 mm per year. The aridity of the region is reduced by sea-mists coming from the coast. It is found in flat to hilly, calcrete, quartz, and shallow loam/sand pavements (Jurgens 1984), in altitude ranges from sea-level up to 450 metres (Acocks 1975). The Succulent Karoo is also found on sandy soils of the coastal plain, and in heavy clayey, stony soils of the foothills and has a number of succulent species, many geophytes and annuals. It has over 5000 species which makes it have the highest species richness for a semi-arid vegetation, with a high concentration of leaf-succulent, low to dwarf shrubs. The succulents include subterranean, stemless dwarf shrubs, chamaephytes to tall shrubs and there is plenty of grass and edible geophytes in spring (Boucher & le Roux 1993). Trees are few and they are mainly found along rivers (Acocks 1975).

There are three variations of the Namaqualand Broken Veld, the typical form characterised by *Aloe dichotoma*, the *Rhigozum trichotomum* veld of the gravelly plains in the Orange River valley, and the False Desert grassveld which results from the grazing out of the Karoo bushes in the more open parts of *Rhigozum trichotomum* (Acocks 1975). The Namaqualand Broken Veld type is in a winter rainfall area that receive rain amounting to about 150 - 300 mm per annum, and is found in altitudes that range from 300 - 1350 metres above sea level. Namaqualand Broken Veld has a lot of succulents most of which are inedible (Acocks 1975). For this Veld type, grasses are rare, the country is broken and steep (Theron & Grobelaar 1990).

Summary

The study area is very diverse in its biophysical setting, natural resources, social setting, human settlement patterns, and its economic, institutional, and legal setting. The concentration of resources in diverse habitats such as wetlands, estuaries and river mouths would have been very attractive to prehistoric hunter gatherers and

hunters as it is to people today. It is therefore expected that a higher proportion of archaeological sites would be located in the immediate coastline.

The identification of environmental variables known to affect archaeological site locations in the study area has, to date, been based largely on informal criteria and the intuitive experience of archaeologists involved. Although this knowledge has been tested empirically, it was not done in a statistically controlled way. However, the information was useful since it facilitated the identification of those environmental variables that influenced the location of at least certain types of sites.

We are now in a position to change the way settlement studies have been done. Move away from presenting knowledge based on the intuitive experience of archaeologists involved. Move towards knowledge about the relations between archaeological resources and the environment that are based on statistically tested empirically observations. The environment does not only provide the scenery for the distribution of archaeological sites, but it is intricately connected with the cultural drama that took place in prehistoric times. The environment both impeded and encourage human existence, hence any attempts at understanding cultural resources has to based on clear understanding of the natural environment.

CHAPTER 6. ARCHAEOLOGY

The distribution and concentration of sites is likely to correlate closely with coastal landforms, dunes and other key environmental variables because people are attracted by the food and shelter they provide. Therefore any conservation strategy directed at managing the environment, needs to acknowledge and take into account the presence of archaeological sites. The inverse is also true, any information about archaeological sites is essential to the effective management of the environment in a holistic manner. For example, if we are to understand the formation and present functioning of dunes, we have to have an insight in their past and the processes involved in their formation.

The archaeological data we collect will help us to understand the evolution and functioning of coastal ecological systems. We can use the data in the formulation of management policies, strategies and guidelines in order to ensure that dune management addresses archaeological sites. In the past that has not always been the case. Most Coastal Zone Management (CZM) programmes have focussed primarily on natural systems - coastal vegetation, soil, geology - and the impacts of human activities - agriculture, pollution, and mining. Coastal Zone Management workers have done little on pre-colonial human processes which have been responsible for altering the coastline.

One of the needs expressed by CZM planners and archaeologists also is the identification of areas where the risk on archaeological sites is high. Most archaeologists involved with Cultural Resource Management 'know' that there are archaeological sites in most of the coastal areas and have an intuitive idea of archaeologically sensitive areas. Unfortunately that kind of an answer is not suitable when dealing with CZM workers who have to balance the needs of conservation with economic development. On the other hand archaeologists are in a dilemma - they are dealing with a resource that is invisible and not easily assessable. Nevertheless, there is a need to move from vague assertions about the presence of archaeological sites to a

structured and logical assertions. Hence the need to use current knowledge about the location of archaeological sites to determine the presence or absence of archaeological sites.

Below is a list of what most CZM planners and workers often need to know:

- Whether there are sites.
- The legal requirements concerning archaeological sites.
- Where the sites are, what information is available.
- The type and significance of sites.
- What to do with these sites, and others that are discovered at later stages.
- Where to go for expert advice and input in the formulating strategies with regards to archaeological sites (Coetzee & Kaplan 1996).

The driving force is the need to provide information about the state of archaeological heritage which, will lead to better informed management. The opportunities to use such information at strategic and operational level are considerable, but at this stage can only be glimpsed. The information will provide support for positive approaches to the protection and management of archaeological resources, and baseline data to endorse professional convictions about the merits of specific judgements. Furthermore the information will help identify those areas where co-operation and the integration of policy initiatives can be most fruitful and of greatest benefit to both the resource and society.

For example the database can be used to determine the relative significance of archaeological sites. For that to be possible archaeologists have to come to the realisation that not all archaeological sites are the same. Some archaeological sites are more significant than others based on factors like the uniqueness of the site and rarity. Significance is by in large based on value judgement, and therefore there will always be disagreements. Nevertheless it is felt that there are clear enough guidelines to make its use meaningful. The significance of archaeological sites can be determined by

looking at the culture of the site, type of the sites, presence or absence of rock art, marine shell, stone tools, ostrich eggshell, fauna, ceramics, lobster, ochre, features like hearths and whether the site is stratified or not.

Archaeological Surveys

Currently the distribution of coastal archaeological sites and our knowledge of these distribution is based on the extent and method of archaeological survey. Unfortunately little of the coastline has been systematically searched which leads to a distorted impression of the distribution and significance of sites.

The total extent of the study area is 16147 km², of which a negligible amount has been systematically surveyed for archaeological remains (see Map 14 in Appendix C). The surveys that have been conducted vary from chance encounters, research surveys, and cultural resource management (CRM) surveys. For the purposes of this study there will be two types of surveys, CRM Surveys and Research Surveys. The reasons for this separation should be self evident. CRM Surveys should by their nature result in a thorough and accurate survey of the area to be developed, whilst on the other hand with Research Surveys there is no obligations to make certain that every square metre is searched and assessed. For the latter surveys some sites are found by chance, despite that, some of the surveys in this group are as accurate as CRM Surveys but the subdivision still applies.

A total of 159.356 km² in the study area forms part of CRM surveys. That means only 0.8 percent of the study area has been surveyed in a systematic and exhaustive manner. Furthermore, most of areas that comprises CRM Surveys are within 1 kilometre of the coastline. That means most of the interior has not been systematically surveyed for archaeological remains. As a result what is likely to emerge from CRM surveys is a picture of human settlement in the immediate coastline.

For the lower tier surveys, Research Survey, a total of 1417.960 km² of the study area has been surveyed - 8.7 percent. Compared to CRM Survey, a significant proportion of Research Survey includes the interior. There are three main areas where these surveys have concentrated, the Langebaan peninsula, the Vredenburg peninsula, and the area between south of Elandsbay and just north of Lamberts Bay. In some areas surveys have been extensive and have gone as much as 19 kilometres inland. These areas are important because they give us a picture of what the hinterland looks like archaeologically, something we cannot infer from the CRM Surveys. In total, 1567 km² of the study area has been surveyed - there are areas where Research Surveys overlap CRM Surveys. Figure 6.1 below show the proportions of the different types of archaeological surveys.

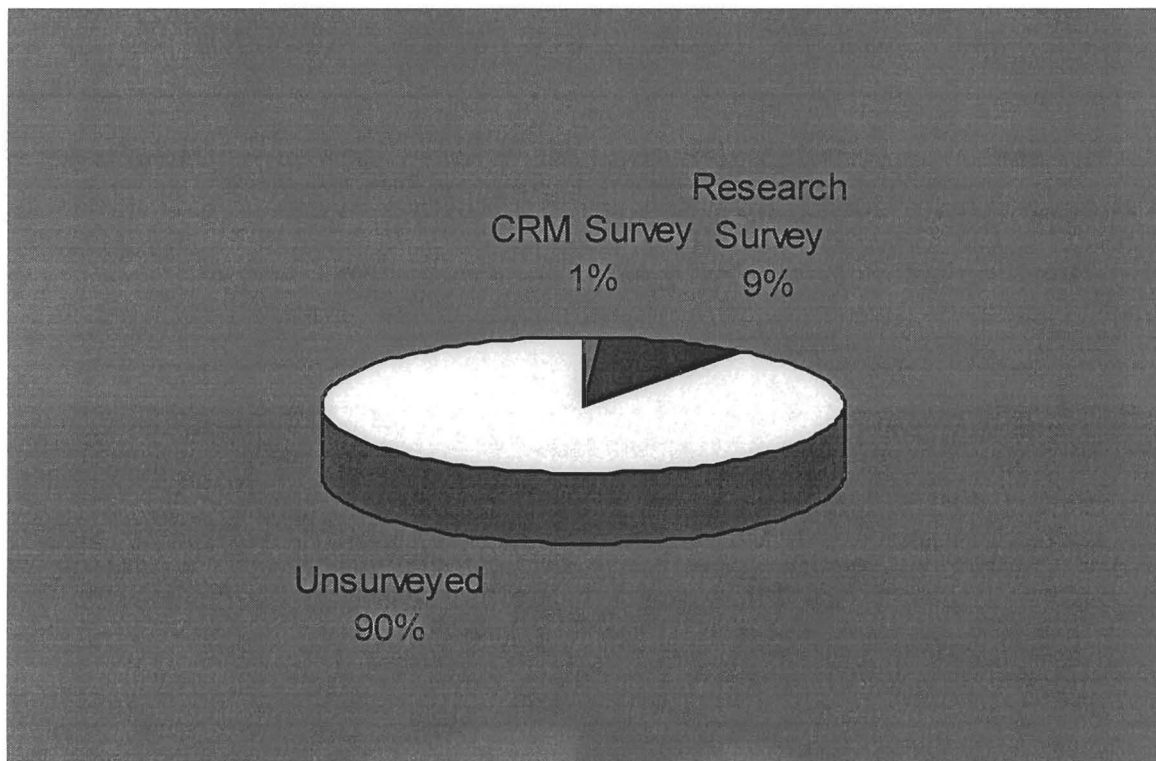


Figure 6.1 Proportion of Various Types of Surveys.

Knowing how much of the study area has been surveyed and the number of archaeological sites can help archaeologist to extrapolate the extent of archaeological resources in the whole area. That only becomes possible by knowing the number of

sites in each of the different surveys. Then it becomes a simple matter of multiplying the known density of archaeological distribution in searched areas with the remainder of the study area. The result of this extrapolation should be taken as an estimate for a number of reasons. First the extrapolation is based on the assumption that all parts of the study area were equally suitable for human settlement. Secondly the estimate is based on a non-probabilistic archaeological samples.

Archaeological Database

For effective management of an archaeological site, it is necessary to know where the site is located, what work has been done on the site, who did the work, what is the potential of the site, and any reference material about the site. Locational information about the sites was acquired from maps and data sheets from the South African Museum, Spatial Archaeology Research Unit and the Archaeology Contracts Office of the University of Cape Town. Most of the sites were recorded as points in 1:50 000 topographical maps and 1:10 000 Aerial Photographs, and some site locations were recorded using the Global Positioning System (GPS). The latitude and longitude positions were entered as decimal degrees.

To date a sum total 2144 archaeological sites have been found in the study area. This number is a result of more than 50 years of systematic surveys on the Cape west coast. The information was collected from site recording forms from various institutions like the South African Museum, the Archaeology Contracts Office of the University of Cape Town, the Spatial Archaeology Research Unit of the University of Cape Town, and other Cultural Resource Management agencies. A database was created outlining as much information about individual sites as possible. For each site the database gives its name, culture, type, presence or absence of cultural materials like ochre, stone tools, rock-art, etc. Furthermore depending on whether the information is available, the database outlines the potential of the site – whether the site has been sampled or excavated - and the presence of any features like hearths, stone circles and burials.

In addition to locational information, the spreadsheet outlines the amount of work that has been done, if any, for each site. Coupled with the amount of work done, the potential of the site is given. That sort of information is necessary for the database if it is to be useful as a management and research tool. For example, researchers and managers will be able to request a list of sites with high potential that have not been sampled or excavated, thereby directing new research on those sites and giving them special attention.

The database is in no way perfect, the need to simplify meant that a lot of valuable information has been left out. For example, with regard the presence or absence of stone tools, the database does not distinguish between stone tools debris and formal tools. The database says nothing about the type of stones, whether the raw materials are silcrete, quartz or shale. To incorporate that level of detail will be cumbersome and might not be necessary for a project of this nature. The objectives of this project are to produce a predictive model and to facilitate CRM initiatives, and the level of detail in the spreadsheet is sufficient. In conclusion it is important to again stress the point that the database is in not complete, it is only a start. When new information becomes available or there are corrections, the database can easily be updated. The database also attempts to simplify information with different levels of accuracy and present it in a uniform manner.

The first column in Table (1) gives the 'Name' of the site. The name is made up of two or three letters followed by a number. The names are the same as the ones giving to a site when it was first recorded and they are unique. Uniqueness is necessary so that the user of the data base is able to enter the name of an archaeological site known to them, and the system will return the attributes of the sites. Furthermore all the names have been entered in upper-case, and because GIS is case sensitive the user need to be careful when using the data base.

The second column indicates the cultural attribute of a site. The categories used are the ones consistent with those used most commonly by archaeologists in South Africa. The guiding reason was the age and technology of the archaeological materials found in the site. The categories are Later Stone Age, Middle Stone Age, and Earlier Stone

Age. Sometimes it not easy to assign an archaeological sites to a cultural category because more than one temporal and technological period is represented. A site could have been in repeated use for sometime in both Middle Stone Age and Later Stone Age. When that is the case, the database indicates that by putting both LSA and MSA in the column for Culture. The breakdown of the archaeological sites in the study area according to cultural affiliations is given in Table 6.1.

Culture	Number	Percentage
LSA	2096	97.76119
LSA and MSA	8	0.373134
LSA, MSA and ESA	2	0.093284
MSA	34	1.585821
MSA and ESA	3	0.139925
ESA	1	0.046642

Table 6.1 Archaeological Sites and their Cultural Affiliations.

The third column in the spreadsheet indicates the ‘Type’ of the site. If the project is to facilitate Cultural Resource Management and used for predictive modelling, it is necessary to differentiate sites according to type. Different occupations and resource procurements resulted in different site types. The variables needed to predict the location of a shell middens are therefore likely to be different from those needed to predict the location of a cave. Furthermore, management of a cave requires different considerations from management initiatives geared towards the management of a shell middens. Table 6.2 is a tabulation of all the archaeological sites and their typology and Figure 6.3 is the graphical representation.

Figure 6.3

Site Type	Number	Percentage
Cave	98	4.5
Deflation hollow	608	28.3
Fish trap	3	0.1
Open site	633	29.5
Overhang	158	7.3
Rock shelter	144	6.7
Shell middens	499	23.2

Table 6.2 Archaeological Sites and their Typological Affiliation.

The sites in the spreadsheet were therefore given site types based from information on the site recording forms. This process was fraught with inconsistencies, because there are no agreed upon site type categories. Individual researchers used categories that they were familiar with, which sometimes meant that two would refer to the same site type but used different terms. Despite that, an attempt has been made to simplify the classifications as much as possible to a more manageable format. For example combining rock shelters, rock ledges, and overhangs into a single category, rock shelters.

The database also attempts to outline the nature of archaeological information available in each site, albeit briefly. The coastal environment present a highly structured and visible pattern of resource availability. The resources are highly varied in behavioural patterns and accessibility, specific in terms of their habitat requirements and subject to a variety of spatial and temporal controls. For each archaeological site the database indicate the presence or absence of rock art, stone tools, shell, ostrich eggshell, ochre, lobster, and any other archaeological remains. The information is simplified such presence is indicated by “1” and absence by “0”. The

point of outlining these categories is that they give some clues as to how important the archaeological sites are and whether they would be worth excavating.

The presence or absence of rock art is a function of a number of factors including geology and topography (Table 6.3). Not all of the study area is suitable for rock art, some areas have no rocky outcrops where the art would be drawn or the geology is not suitable. It is hoped that the presence or absence of rock art will closely correlate our expectations given the topography and geology of certain areas. For example, one would expect archaeological sites with rock art to be located in a topographically varied landscape, for example the region between Berg River and the Olifants River. In addition, they will be located in geological strata that lend themselves to the formation of caves, for example the Cape Supergroup. According to Parkington *et al.* (1988) the presence of rock-art is to some extent merely a reflection of the availability of a suitable canvas. However, the presence or absence of rock-art is also informative on a range of issues including prehistoric settlement.

Rock Art	Number of Sites	Percentage
'0'	1802	84.05
'1'	342	15.95

Table 6.3 Presence and Absence of Rock Art.

Marine shells are a result of the exploitation of the coast for marine resource consumption (Table 6.4). The likelihood of finding marine shell in archaeological sites is greater the closer the sites are to the coastline. That likelihood is further increased by the presence of rocky outcrops along the coastline. Nevertheless it is still possible to find marine shell in archaeological sites that are located some distance from the coastline. That is because people were moving between the coast and the inland, and in the process moved objects to and fro.

Patella granatina, *Patella granularis* and *Patella argenvillei* were the 3 species that were heavily exploited. Other important species were black mussel - *Choromytilus meridionalis* - and *Patella barbara*. Shell middens offer information in estimating aspects of prehistoric diets, patterns of selectivity in exploitation, environment conditions, seasonal patterns of gathering, and excellent for the preservation of bone and other organic material. Shell remains can also be used as a quantitative measure of changing species frequencies, used to measure changes in size and for microscopic analysis of growth structures (Parkington *et al.* 1988)

Marine Shell	Number of Sites	Percentage
'0'	470	22
'1'	1654	78

Table 6.4 Proportion of Sites with and without Marine Shell.

One of the materials that survives in archaeological sites are stone tools or debris from stone tool manufacturing. Stone tools are sometimes the only indicator of past human settlement because their preservation is excellent. Whereas bone from Middle Stone Age sites is likely to be destroyed by the elements, stone tools are likely to survive. Stone raw material can give us insight in the movement of raw materials across the landscape by toolmakers, inform us about prehistoric land-use arrangements and any changes in the scope of movement or access through time. However this seemingly neat package is complicated by the recognition that specific raw materials are often preferred for particular tool types, the frequency of tool types changes through time and that some resources of raw material may be covered or exposed over the millennia (Parkington *et al.* 1988).

The range of stone tools includes flakes, cores, hammerstones, grindstones and other miscellaneous retouched pieces. The raw material used to manufacture the tools included chalcedony, chert, quartz, quartzite and silcrete, in fact any isotropic rocks which can be flaked in a controllable way.

Stone Tools	Number of Sites	Percentage
'0'	799	37.27
'1'	1345	62.73

Table 6.5 Percentage of Sites with and without Stone Tools.

Ostrich eggs were used by prehistoric people as a source of protein and the eggshells were subsequently used as water containers and for making decorative beads (Table 6.6). Broken ostrich eggshells that were used as water containers are a common occurrence in most archaeological sites on the Cape West coast and are recognised by the smooth rim of the opening. Furthermore, thousands of ostrich eggshell beads have been found on archaeological sites.

Ostrich Eggshell	Number of Sites	Percentage
'0'	1321	61.62
'1'	823	38.38

Table 6.6 Percentage of Sites with or without OES.

The presence of faunal remains attest to the exploitation of terrestrial animals like dassies, steenbok, grysbok, dune mole rat and tortoise by prehistoric people (Table 6.7). Hunting, as part of a subsistence package including gathering, played an important role in the lives of prehistoric people. The animals provided protein, fat, and their skins provided leather for clothes and blankets.

Fauna	Number of Sites	Percentage
'0'	1798	83.86
'1'	346	16.14

Table 6.7 Percentage of Sites with or without Faunal Remains.

Pottery remains provide regional and chronological information. First, it is thought that the presence of pottery post-date 2000 years and the first appearance of ceramics on the Cape West coast is agreed upon to be around 2000 B.P. Which means that the presence of ceramics can be used for dating purpose, because they are a strictly Later Stone Age phenomena. Secondly, pottery remains from different parts of the country indicate that there are variations in both shape and decoration. The ceramic remains found in the study area include remains of broken reconstructable pots and fragments of pots (Table 6.8).

Ceramics	Number of Sites	Percentage
'0'	1606	74.91
'1'	538	25.09

Table 6.8 Percentage of Sites with or without Ceramics.

The presence or absence of crayfish could have been incorporated with the rest of marine organisms, but it was felt that their presence or absence need to be highlighted (Table 6.9). In the archaeological record crayfish are represented by their mandibles. These mandibles can supply important information about the consumption of crayfish by prehistoric people. They can tell us about the antiquity of crayfishing, hence more information on the consumption patterns of prehistoric people. Furthermore they can tell us about the kinds of places in which people chose to catch the crayfish, and changes in conditions of the water bodies in which people caught crayfish.

Lobster	Number of Sites	Percentage
'0'	1735	80.93
'1'	409	19.07

Table 6.9 Percentage of Sites with or without Lobster Mandibles.

Ochre was used as a pigment in making paint that was used for rock art (Table 6.10). The raw material was not available everywhere, but in specific places where it was mined and used to make the pigment. Therefore you would expect its distribution to correlate closely with geology and areas where archaeological sites with rock art are located.

Ochre	Number of Sites	Percentage
'0'	2098	97.86
'1'	46	2.14

Table 6.10 Percentage of Sites with or without Ochre.

Due to persistent high winds especially in summer and fairly sparse vegetation some open archaeological sites became deflated and the stratification of the remains was lost. Knowing whether a particular archaeological site is stratified may be useful when one needs to determine which sites to excavated (Table 6.11).

Stratified	Number of Sites	Percentage
'0'	2030	94.68
'1'	114	5.32

Table 6.11 Proportion of Stratified Sites.

Summary

The results highlighted above are a results of decades of archaeological research conducted in the study area. So far only 10 percent of the study area has been surveyed for cultural resources and 2144 archaeological sites have been discovered. An important consideration is the issue of data quality and consistence. Most of this archaeological site data is incomplete, of varying quality, lacking key information and is repetitive. Despite these obvious shortcomings there is enough information to show the general pattern of spatial distribution.

The point about most of the categories that the archaeological sites have been divided to is that they give some clues about the importance of these sites, and whether they would be worth excavating. Furthermore the information in the database can be used as a research tool and a management tool, and it goes some in trying to address some of the questions often asked by planning agencies. This information is also important for research purposes. The information can be used for archaeological reconstruction of prehistoric subsistence economies. Furthermore the information can be used to measure the degree to which available resources were actually made use of, and integrated within a subsistence economy.

CHAPTER 7. CONCEPTS

Environmental resource problems stem from inefficient utilisation - the tendency to try to conserve resources that are easily priced and we have detailed knowledge of, but not others that we may not know about or understand well. This is often referred to as “Eco-inefficiency”. The opposite is “Eco-efficiency”, managing to take into consideration all available resources and with proper knowledge know what to conserve and in what proportion (DEA&T 1993).

All of the above-mentioned notions, - Eco-efficiency, ‘prices’ - their realisation depends on knowledge of how much of the resource is available. For example, the aim of the research that is being done by the Sea Fisheries Institute is to provide the best possible scientific advice for resource management. Information obtained through research forms the basis for recommendations regarding Total Allowable Catches or TACs - that part of the resource that may be utilised every year without damaging the resource -, minimum sizes, closed seasons, and other regulatory measures. These recommendations are formulated by working groups and serve as the basis for the resource management advice that will ultimately be given. The Sea Fisheries Advisory committee combines the institute’s pure scientific recommendations with socio-economic and other considerations in order to formulate recommendations that have as their purpose the protection of the resources and the welfare of the fishing communities. The influence of the environment on marine resources is thoroughly taken into account when resource assessments are being done. The program for environmental monitoring includes the collection, analysis and interpretation of important environmental data applicable to Southern Africa. The compilation of regulations that will provide for the orderly utilisation of resources according to the above guidelines, the issuing of the necessary permits, and the registration of boats are the responsibility of the administrative personnel of Sea Fisheries.

Estimating The Resource

Like any other conservationist, archaeologists need to know or have a reasonable estimate of the resource with which they are entrusted. The difference is that archaeological resources are not like other resources - archaeological resources have a fixed supply, and furthermore are non-renewable and not visible, therefore difficult to audit. The archaeological sites that we currently know of come from diverse and different sources. How do we develop a working approach that is going to be unbiased and representative? There are a number of ways to fulfil that objective, in the first instance we could rely on random isolated finds and direct our efforts into taking care of what we know of. This approach has been responsible for the discovery and conservation of many important sites, but it is just not good enough to provide a reliable strategy over a large area because there is no consistent co-ordination of surveys therefore repetition is common. Some archaeological sites get recorded more than once, and certain types of archaeological sites are over represented in the sample. Also there is no prioritising of important archaeological sites or areas.

Alternatively, and more satisfactorily, we can rely on research surveys that are conducted by universities, museums and other research institution with an interest in the research of archaeological resources. These research surveys are important because they are conducted in a consistent manner with explicit purpose of addressing a specific research question. A number of research surveys have been conducted on the study area mainly by the Spatial Archaeology Research Unit of the University of Cape Town and other researchers connected to the University of Cape Town and the South African Museum. The negative side of this strategy is that the archaeological sites recorded and conserved will tend to conform with the research interests of the recording institution which are most likely to change, instead of embracing a holistic approach to conservation of cultural heritage.

Another alternative is to rely on the results of Cultural Resource Management surveys that have been conducted in the study area. A number of CRM practitioners have done extensive and thorough work throughout the Cape West Coast. These surveys were

done for areas that were earmarked for mining and development, both residential and commercial. Conservation strategies that rely solely on CRM surveys will tend to take care of archaeological sites that are located in areas that are used by contemporary people - for residential and industrial purposes - hence they will not necessarily give us a better understanding of prehistoric settlement patterns.

A more useful approach will be to incorporate all the survey results, and something 'more'. The results from CRM surveys are necessary because they incorporate cultural resources most threatened by human development. Results of Research surveys will include archaeological sites that were discovered in a process of answering a specific question about past societies. Random isolated archaeological sites are necessary because they are likely to provide a new twist, angle in our quest for understanding of past settlements. A twist that is likely to provide new problems and understanding about the past. That something 'more' is what this project is all about. If we only rely on the 3 approaches in the conservation of archaeological sites, the chances of learning something else are diminished. By using only the three approaches we would only be conserving what we know of, which is likely to be only a small fraction of the total resource.

In the quest to devise a management plan for the archaeological sites, the results of all the archaeological surveys that have been conducted on the study area will be combined to form a data sample for this exercise. As a sampling strategy this approach is not ideal because it is likely to perpetuate the biases from the original surveys, but it will have to do for two reasons. Firstly, a new survey would be expensive and secondly it would be time-consuming to conduct a survey specifically for this project. Nevertheless it is felt that the information available will be adequate for the project.

Management Plan

Human exploitation of resources is a one-way process because human populations are not regulated by natural interactions. There is no built-in biological feedback mechanism to limit over-exploitation of resources. Furthermore, humans have the capacity to indirectly influence resources by modifying the environment, and they are extreme generalists in terms of the resources they use. Different resources differ in their susceptibility to exploitation because of their characteristics, hence there is a need for different management strategies.

Environmental management is a complex structure of biological, social, cultural, legal and economic factors. Recent aims of management have broadened to include the conservation of biotic and genetic diversity and to maintain the structure and the functioning of the whole ecosystem (Norse 1991). Sociological factors include the fact that management programmes often impinge on the viability of economic ventures and the success of population maintenance. Cultural factors refer to the ease with which one can persuade people to switch to alternative resources. Socio-economic factors is concerned with how we can diversify the use of natural resources and decrease the dependence on one resource. The complex nature of these factors that influence management illustrate the integrated nature of resource management and any management need to take all these factors into account in order to succeed.

Possible complications with management plans include concerns whether the proposed measures are appropriate, and whether they can be practically implemented. In addition, it is almost impossible to produce a plan that meets the needs of all interested parties and contingencies. There are always conflicts between users, managers and developers. Also, as knowledge increases, previous measures, which have been legislated in good faith, may prove ineffective or inadequate.

Taking the above-mentioned concerns it would seem that the primary objective is to devise a proper management plan for archaeological resources. In doing so we either try to improve traditional approaches - legislation and policing, or rely on something else to supplement the traditional techniques of legislation and policing. A good place to look at will be at other people involved in conservation exercises and see how they go about it. Alternative management techniques that equally embrace and at the same time move away from the traditional approaches.

At present archaeological sites are protected based only on the merits of individual sites, unlike other conservation measures that look and protect resources as systems. Each site is protected on its merits without any consideration of other archaeological sites, or other groups of sites and how a particular site fits in the whole scheme of things. This is the case because archaeological resources are not looked upon as systems, neither ecological *systems* nor *natural systems*. Relations between sites do not correspond with relations between organisms. Although this may be the case, there is scope in looking at the settlement arrangements of earlier people as systems rather than as isolated and distinct events.

One approach to the development of a conservation strategy is to argue that enough archaeological sites are already protected in the established reserves. The way forward is to determine how many archaeological sites are currently located in National Parks, Nature Reserves, and other protected locales. National legislation that applies to these areas mean that any archaeological site within these areas is protected to a degree in the sense that any development inside the protected areas is monitored and controlled. We can then compare the profile of the archaeological sites inside protected areas with that of all the archaeological sites. If the number of archaeological sites within these protected areas is 'sufficient' and similar in profile to the total number of sites a case can be made that enough resources are under proper protection. Determining what is 'sufficient' will be a major breakthrough.

An alternative, more pro-active approach is to look at the conservation techniques that are employed by natural scientists. Alternative management techniques that attempt to

conserve whole social systems, and the biological and environmental processes that maintain these systems. Management techniques that are going to consider factors like representativeness, uniqueness, biotic diversity, endemism, fragility, pristineness, aesthetic appeal, occurrence of rare or endangered species (Rabe and Savage 1979; Emanuel *et al.* 1992). That sort of thinking follows on current international trends in conservation exercises, which are not centred on the conservation of individual charismatic species (Cowling *et al.* 1998). This implies that we need to know more than simply the distribution of archaeological resources in the landscape. We need to know not only how archaeological resources are distributed across the landscape but the processes that led to these resources. We need to know the distribution of different kinds of archaeological sites on the landscape and the processes that led to that patterning. Thus, we need to know the physical and biological environment that acted as a vehicle for evolution of the distribution of archaeological resources.

Any attempts to formulate alternative management techniques in an already established discipline is always likely to be fraught with problems. As it has been pointed out in the introduction the relevance of concepts from life sciences like biodiversity, uniqueness/endemic, pristine versus disturbed regions, rarity, minimum viable size of conservation areas and redundancy of objectives, is relatively unknown in archaeology. Nevertheless, an attempt will be made in this project to introduce these concepts in this exercise in order to explore their relevance. The problem is that some of these depend on value judgement, are neither quantifiable nor objective measures. In addition, some criteria are in conflict - uniqueness *versus* representativeness (Dye *et al.* 1994). The idea will be to use these concepts with regard to archaeological sites in order to determine whether there are areas in the landscape that fulfill all these conditions. If that is the case the areas can be viewed as potential 'archaeological reserves' in much the same way we look at nature-reserves - a 'patch' strategy. Although this is the first time that this has been suggested as an option in South Africa, world-wide the concept of 'archaeological reserves' is not entirely new or anyway unique. The ICOMOS Charter for the Protection and Management of the Archaeological Heritage, the UNESCO Recommendation Concerning the Preservation of Cultural Property Endangered by Public or Private Works, and the European Convention on the Protection of the Archaeological

Heritage all have suggested the creation of 'archaeological reserves' as part of an integrated approach to the conservation of cultural resources (ICOMOS 1990; UNESCO 1968 & ECC 1992 in Appendix B).

Although the concept of 'archaeological reserves' is a new entity in South Africa, a number of important archaeological sites or resources have been included in the South Africa Natural Heritage Sites. They are the Klasies River Caves, Bushmans Kloof, and Paardenberg Bewaria. The common theme with these sites is the fact that the archaeological resources or cultural resources located within them were not the reason for the protection of these areas.

In order to determine the parcels of land that will form these 'culture-reserves', the study area will be subdivided by using a regular grid over the area. For this project, grids of two different sizes will be used in order to determine which size best represent the spatial patterning of archaeological sites, and as a heuristic device to show how solving the problem has various facets. The one grid will be 10 kilometre x 10 kilometre in size and the second one will be 5 kilometre x 5 kilometre. The two sizes were decided upon for two reasons, firstly anything smaller than that would have slowed analysis and secondly, anything bigger would have been too big to give meaningful results. For each grid square an number of analyses will be conducted in order to determine its suitability as a 'culture reserve'. The analyses are to enable us to measure for each grid square density, archaeo-diversity, rarity/uniqueness and endemism of archaeological sites located in the square. These analyses are based on what is commonly used by botanists, zoologist and other biologists working in conservation.

Density

The notions of density has had a long, intuitive formation in archaeology, a consequence of social and environmental conditions (Jones & Leonard 1989). Density measures the number of species present in a given area. This index can also be viewed

as an areal species richness measure. The density index is measured by the following equation:

- $\text{Density} = \text{Number of Artefacts} / \text{Area}$

And because the density index is dependent on area, we have to be careful when measuring the index, specifically for this project where not the whole study area has been surveyed for archaeological sites. In addition we have to be careful when measuring the density index for each grid because for some grid squares, only a section has been surveyed therefore any density measure for that grid will be applicable for that section, not the whole grid square. It is important to take this into account because it has the potential to flag a low density grid as having high density.

Diversity

Artifacts are a paramount source of data, therefore a conceptual substitution of artifact types for species allows researchers to formally apply the concept of diversity to archaeology. The basic matter of diversity is how archaeological record differs along gradients of various sorts, for example across space. Most often researchers have confused diversity with variation. Diversity is not the same as variation, but rather it is a measure of variation (Jones & Leonard 1989).

Diversity indices embody three distinct aspects, richness, evenness, and heterogeneity (Jones & Leonard 1989, Kintigh 1989). Richness is a measure of the number of species or artefact type present in a collection containing a specified number of individuals. The measure provides a means by which differences or similarities in collections can be measured and compared. There are various ways to measure richness. It can be measured by a direct species count, but the problem is sample size dependence (Kintigh 1989), especially on the richness index. For example imagine you have only 3 items in a sample, you cannot have a richness less than one or more than three, no matter how many categories have been defined. With a larger sample,

one can expect that there will be no appreciable sample-size effect. A more realistic approach is to assume that the relationship between species and individuals is constant and quantifiable within communities (Bobrowsky & Ball 1989).

Evenness represents the absolute distribution of individuals across all species, or to put differently it is the similarity in abundance of several species in the community. As a measure, richness alone fails to provide insight into particular underlying abundance distribution. There is a need to know if all species are equally abundant or certain species are more abundant than others are. This can be attained by plotting the abundance of species in terms of their rank order from the most abundant to least abundant (Bobrowsky & Ball 1989).

Heterogeneity assesses the variability in both the number of species and abundance of individual species with a single value (Bobrowsky & Ball 1989). The heterogeneity index encompasses both the richness and evenness measurements under a single value. One widely used example of a heterogeneity measure is the Shannon and Weaver index, also referred to as the information statistics. The use of the heterogeneity index must be viewed with caution, because according to May (1981) the use of a single value masks the different properties of the richness and evenness measures.

Diversity measurement rests on an unambiguous classification of the subject matter. The subject matter must be mutually exclusive, exhaustive and composed at the same classificatory level. Samples must be generated either randomly or in some other manner be representative with respect to the gradients over which differences are evaluated (Jones & Leonard 1989). The measures may be applied to any data set composed of individuals, which can be allocated to classes. What is needed is a working data set which is representative of U - broader set of interest. Value n - individuals n_1, n_2, \dots, n_i existing in the set. Lastly c - classes $c_1, c_2, c_3, \dots, c_j$ into which the individuals are apportioned (Rindos 1989).

Diversity has the ability to summarise a rather unspecified sort of variability in an archaeological assemblage (Kintigh 1989). The strength of diversity is its wide

applicability. The structure of most archaeological data invites quantitative description, and diversity constitutes a measure of our perception of these data. It provides the means to examine the nature of processes that govern the representation of different classes of phenomenon in the archaeological data (Jones & Leonard 1989). The weakness of diversity is the tendency to make us believe that we have an insight into the data when we merely have created a mathematical epiphenomenon. Furthermore diversity indices measure the form data takes, not content or meaning (Rindos 1989). In addition two data sets may differ in every conceivable manner except number of classes and number of individuals in each class, but still produce exactly the same results.

In this project, diversity theory will provide informative quantitative indicators of what archaeological sites to protect. This is a change from policies that operated in an analytical vacuum where there it is not clear what to conserve or what are the relevant trade-offs. The stated aims and objectives of most conservation-minded individuals and groups is to maintain the maximal amount of diversity. If diversity cannot be measured, it is difficult to comprehend how rational decisions are supposed to be made about how best to conserve resources.

The biological and physical conditions of an area will determine how desirable an area is as a reserve, and the socio-economic conditions determines its effectiveness. The function of a reserves are the protection of archaeological sites of particular interest, preservation of entire functioning cultural communities, and the maintenance of diversity in perpetuity (Soule' and Simberloff 1986). In addition, reserves have educational and recreational roles, and are used for research and monitoring the resource.

Rarity

Blanket protection of archaeological sites is an unrealistic expectation. The conservation of archaeological sites and their preservation is a costly business which is often in conflict with socio-economic development. In the past archaeologists have

had to make compromises about which sites to protect and which sites to lose. To date there are no clear guidelines as to how to go about making those decision. One way to make those decisions is to devise a system based on rarity of an archaeological site and its significance on a global and regional scale. Even then, there is a lot of subjectivity in the decision making process. What is needed is a process that will take into account the rarity and significance of an archaeological site, but at the same time try to objectified the decision making process - an almost impossible task because whatever decision one make will be based on value-judgements. An even more alarming factor is the fact that not all of the study area has been surveyed for archaeological resources. So, whatever management initiatives are put in place they will only be protecting what is currently known, not the unknown - which could be even more valuable and certainly more in danger.

As Dye *et al.* (1994) has pointed out, some of the criteria used to flag areas as reserves depend on value judgement, neither easily quantifiable nor objective, and are in conflict with other measures. It would seem that rarity is one such variable. Rarity is based on value judgement because what might seem rare to one person might be fairly common for another person. Rarity is not quantifiable nor is it objective. Despite these shortcomings it is still a useful criteria for the management of archaeological sites. For example, imagine if the site of Great Zimbabwe was located on a grid square with no other archaeological sites. With the other indices - density and diversity - the grid square, hence the site will not be included in the list of conservation worthy areas. So, by including rarity in the selection criteria for reserves, there is still scope for the inclusion of charismatic and 'sexy' archaeological sites in the management plan.

Summary

The European Cultural Convention and ICOMOS encourages the creation of 'archaeological reserves', even where there are no visible remains on the ground, as a management approach for the conservation of cultural resources (ECC 1992; ICOMOS 1990). Neither the ECC nor ICOMOS present a framework of how one goes about establishing 'archaeological reserves'. One way that archaeologists can go about

creating 'archaeological reserves' is to look at sites and evaluate them on the scientific, aesthetic, cultural, and other values. This approach is based on value judgement and is not objective. What is aesthetically pleasing to one person can be an eyesore to another person. Furthermore there are no quantifiable measures for scientific, aesthetic, and cultural values. Hence this approach is likely to be fraught with problems and disagreements. An alternative approach is to look at how biologists or natural resources managers tackle similar problems. Hence the attempt to introduce the use of concepts such as density, diversity and rarity in the management and conservation of cultural resources. The relevance or the usefulness of these analyses is unknown, but their use is a positive step towards establishing a framework for the establishment of 'archaeological reserves'.

Once all the analyses have been made, all the grid square with high measurements will be regarded as good proxy for the 'archaeological reserves'. Two scenarios are possible, first the grid squares with elevated measurements will be close enough to each other to form distinct areas that can be set out as 'archaeological reserves'. The second possibility is that they are scattered all over the study area such that there are no regions that qualify to be 'archaeological reserves'. If the latter event is true it would mean that the patch strategy does not work or the measurements of diversity, density and rarity are not useful with this particular aim in mind for archaeological resources. Then the option will be to continue with the present non-patch strategy of blanket protection of all archaeological sites.

CHAPTER 8. PROJECT OUTCOME

The first section in this chapter will outline statistical inferences on the distribution of archaeological sites in the study area in relation to environmental variables. For example I will attempt to answer questions if ‘archaeological sites are more common in some geological formations than others?’ The results of the statistical inferences will be used as a basis for the development of an Archaeological Sensitivity Model. The Archaeological Sensitivity Model will attempt to predict the location of archaeological sites in the parts of the study area that have not been surveyed, based on the locational information of known sites.

The approach used for this project is a graphical methodology using a map overlay technique. The different environmental variables are represented on separate computer map layers with the distribution of archaeological sites in order to determine and identify areas that attracted prehistoric settlement. Then the apparent association between archaeological sites and various environmental variables will be evaluated for significance using statistical techniques, for example Kolmogorov-Smirnov and Chi-squared Goodness of Fit test.

Archaeological Sensitivity Model I

The Archaeological Sensitivity Model will be developed using the distribution of archaeological sites in the study area. The model will be developed with the basic assumption that all archaeological sites are the same and will contribute equally in the formation of the model. Furthermore the archaeological sites will not be separated into temporal or functional types during the development of the model.

Rocky Shoreline

The coast especially the rocky shoreline, which is the land/sea interface, because of abundance of resources is likely to attract people in the past. The concentration of resources from diverse sources such as wetlands, estuaries and river mouths would have been very attractive to prehistoric communities as it is to people today. Therefore it is expected that a higher proportion of archaeological sites would be located in the immediate rocky shoreline.

The average distance from the rocky shoreline for all archaeological sites is 15.2 kilometers, with a minimum distance of 0.005 kilometers and a maximum distance of 54 kilometers, and a standard deviation of 17.268 kilometers. What is of interest is the answer to the query: 'How many archaeological sites are within x kilometers from the rocky shoreline?' Table 8.1 give the results of the query for x = 1, 2, 3, 5, 10, and 20 kilometers respectively.

Distance(in km)	%Total Study Area	%Searched Area	%Sites
0 –1	2.7	9	36.2
1 – 2	2.9	8	13.6
2 – 3	3.1	7	5.9
3 – 5	6.8	11.2	9.4
5 – 10	18.9	23	12.08
10 – 20	39.66	32	19.02
> 20	25.94	9.8	3.8

Table 8.1 Percentage of Sites in Sample Strips along Rocky Shoreline.

More than a third of the archaeological sites are located within 1 kilometre of the rocky shoreline (see Table 8.1), an area that forms only 2.7 percent of the study area. In addition only 9 percent of the surveyed area is within 1 kilometre of the rocky shoreline. The area between 1 and 2 kilometre from the rocky shoreline has 13.6

percent of the known archaeological sites located in it, but only forms 2.9 percent of the study area and 8 percent of the surveyed area. For the rest of the sample strips around the rocky shoreline the percentage of archaeological sites is always less than the percent of the sample strips that have been surveyed. The percentages of archaeological sites are 5.9, 9.4, 12.08, 19.02 and 3.8 for sample strips 2 - 3, 3 - 5, 5 - 10, 10 - 20, and greater than 20 kilometers respectively.

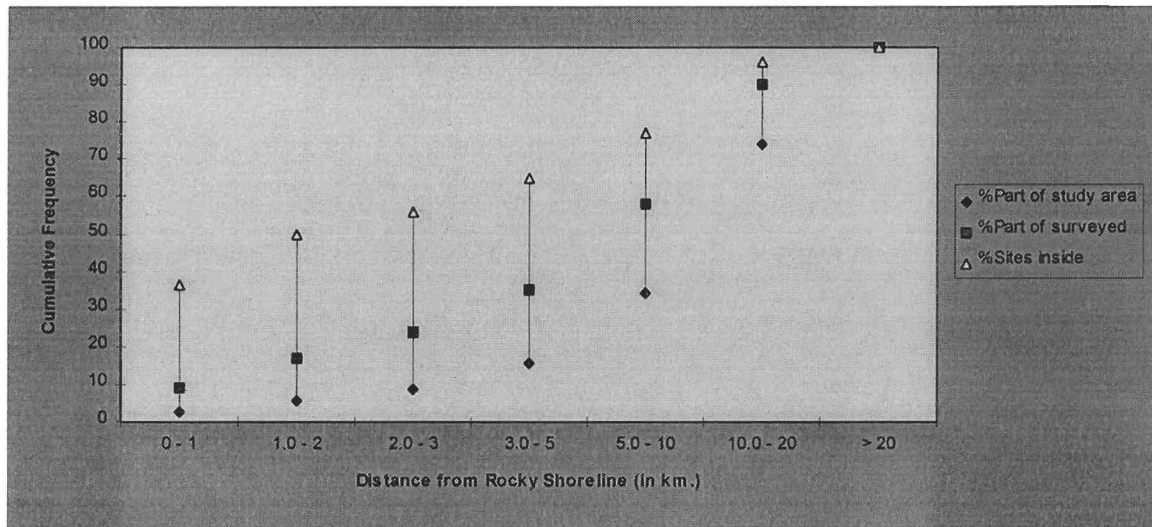


Figure 8.1 Cumulative Percentage Curve of Sites Along the Rocky Shoreline.

The cumulative percentage curve of archaeological sites, percentage part of study area, and percentage part of surveyed area with regard the rocky shoreline are given in Figure 8.1. An obvious question to ask is whether the relative proportions of archaeological sites in each range is significantly higher than the area that has been surveyed in each range. The reason for using the area surveyed should be clear because not all of the study area has been surveyed for archaeological resources. As a result it is possible that the current distribution of archaeological sites is a function of the surveyed areas. The Kolmogorov-Smirnov test will be used to test the null hypothesis and its alternative :

H_0 : Archaeological sites are uniformly distributed on all sample strips.

H_A : Archaeological are not distributed uniformly on all sample strips.

The results of the Kolmogorov-Smirnov goodness of fit test are determined by the values of $D_{\max_{\text{obs}}} = |\text{rel } Fi - \text{rel } \hat{Fi}|$, which is the largest difference between observed Cumulative Percentage Curve - $\text{rel } Fi$ - and the expected Cumulative Percentage Curve. Critical values for this test statistic are referred to as $D_{\alpha,n}$ and are found in most statistical tables. If $D_{\max_{\text{obs}}} \geq D_{\alpha,n}$, then H_0 is rejected at the α level of significance. The results of the Kolmogorov-Smirnov goodness of fit test for the distribution of archaeological sites near the rocky shoreline are given in Table 8.2.

	$D_{\max_{\text{obs}}}$	$p = 0.05$	$P = 0.01$	$P = 0.001$	
Sites vs. Area	0.496	0.02933	0.03515	0.042102	Reject H_0
Sites vs. Survey	0.328	0.02933	0.03515	0.042102	Reject H_0

Table 8.2 Results of Kolmogorov-Smirnov Test.

The Kolmogorov-Smirnov goodness of fit test (see Table 8.2) confirm - that the archaeological sites are not distributed uniformly in all the sample strips away from the rocky shoreline. Looking at Table 8.1 it is clear that there are significantly more archaeological sites located with 1 kilometre, and between 1 and 2 kilometre of the rocky shoreline relative to the proportion that has been surveyed.

The next step is to determine or point out the areas that have a 'high', 'medium' and 'low' potential for prehistoric settlement. These are then weighted based on the magnitude of the difference between the percentage of archaeological sites and percent of surveyed areas in that particular sample strip. If the percentage of archaeological sites is more than 50 percent more than the percent of surveyed area the weight is 5, for a difference of more than 10 percent, the weight is 4, for a difference that is between 10 percent and -10 percent the weight is 3, less than -10 percent the weight is 2, and for less than -50 percent the weight is 1.

Distance(in km)	Potential	Weight
0 – 1	Very High	5
1 – 2	Very High	5
2 – 3	Low	2
3 – 5	Low	2
5 – 10	Low	2
10 – 20	Low	2
> 20	Very Low	1

Table 8.3 Archaeological Potential of Sample Strips along Rocky Shoreline.

Table 8.3 shows the archaeological potential and relative weights for all the sample strips around the rocky shoreline. The weights for distances within 1 kilometre and between 1 and 2 kilometre of the rocky shoreline are 5. The high archaeological potential of areas close to the rocky shoreline is not surprising. The resource potential of the rocky shoreline is immense and would have been very attractive to prehistoric people. The rock platforms along most of the coast act as a substrate for a rich marine life. The rocky shoreline is the habitat where most of the species of animals of potential economic importance to people occur. There are seal, birds, crayfish, limpets and black mussels. For distances further than 2 kilometers from the rocky shoreline the archaeological potential decreases substantially to 2.

Elevation

The impact of climate on the environment is a function of a number of factors including topography. For example, the amount of sunshine on a sloping terrain is a function of slope and aspect, which are both, depended on topography, and obviously season. In addition to absolute topographic values what is important is the topographic

variation of a landscape. Topographic variation influence factors like run-off, erosion, and soil depth, hence can influence human settlement.

The study area is moderately high with most of the area below 200 meters above sea level. The lowest elevation value is 0 meters and the highest is 563 meters above sea level. South of Baboon Point the main feature is the dramatic variation in topography over short distances. North of Baboon Point although the absolute elevation values are more or less the same, the difference is that topographic variation is gradual over long distances.

DEM(meters)	Area Study Area	%Part of surveyed	%Sites within
<= 50	22.57	40.05	65.48
50 – 100	21.82	24.79	14.62
100 – 200	41.19	32.904	16.48
200 – 300	11.89	2.052	3.05
>= 300	2.53	0.204	0.37

Table 8.4 Elevation Zones and Proportion Archaeological Sites

Table 8.4 show that 65.48 percent of archaeological sites are located at altitudes less than 50 meters above sea-level. Only 22.7 percent of the study area fall in this range and 40.05 percent of the surveyed areas are located at altitudes less than 50 meters above sea level. Figure 8.2 shows the cumulative percentage curve for the distribution of archaeological sites in the different elevation zones of the study area and surveyed areas.

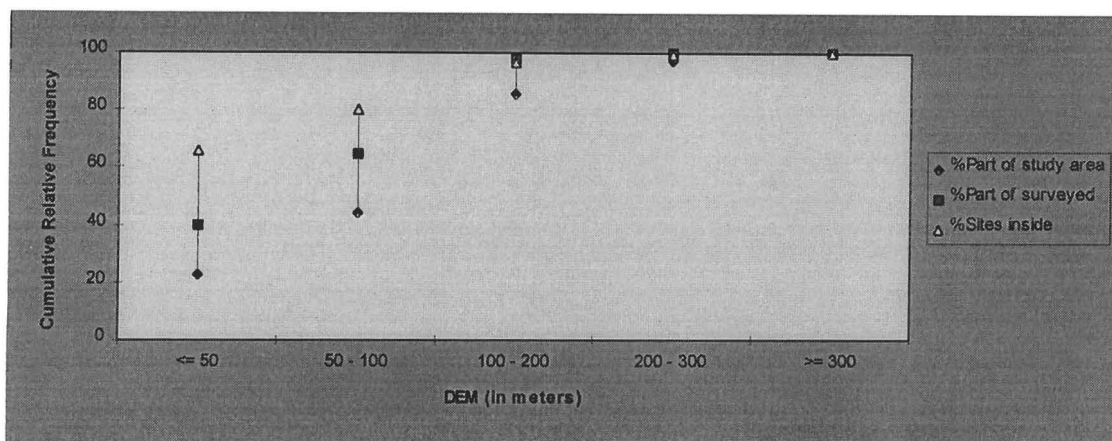


Figure 8.2 Cumulative Frequency Curve for Sites in Elevation Zones.

The obvious question is whether the proportion of archaeological sites within the different DEM-sectors is a function of the areas in the surveyed area that are formed by the different DEM-sector. The Kolmogorov-Smirnov test is used determine whether the null hypothesis or its alternative is true :

H_0 : Archaeological sites are uniformly distributed.

H_A : Archaeological sites are not uniformly distributed.

	$D_{max\ obs}$	$p = 0.05$	$p = 0.01$	$p = 0.001$	
Sites vs. Area	0.4291	0.02933	0.03515	0.042102	Reject H_0
Sites vs. Survey	0.2543	0.02933	0.03515	0.042102	Reject H_0

Table 8.5 Kolmogorov-Smirnov Test Result for Site Distribution.

The results of the Kolmogorov-Smirnov test are given in Table 8.5. The null hypothesis is rejected at all significance levels in favour of the alternative hypothesis that archaeological sites are not distributed uniformly in all elevation levels. The potential for archaeological sites in different elevation levels is given in Table 8.6.

DEM(in meters)	Potential	Weight
<= 50	Very High	5
50 – 100	Low	2
100 – 200	Low	2
200 – 300	High	4
>= 300	Very High	5

Table 8.6 Archaeological Potential of Elevation Zones.

According to Table 8.6 there are three elevation levels with ‘high’ to ‘very high’ potential for archaeological sites, areas below or equal to 50 meters above sea-level, areas with elevation level between 200 meters and 300 meters above sea-level, and areas above or equal to 300 meters above sea level.

Aspect

Aspect measures the orientation of slopes - the down-slope direction of slope - which influences shelter from winds, exposure to sunlight and visibility in a particular direction (Tapia & Tapia-Recillas 1996). For example, the daily incoming solar radiation is a function of slope and aspect. In midsummer, solar radiation increases with latitude for the North, Northeast/Northwest and East/West aspects. As results in the study area people might prefer locating their settlements on West and south-west slopes in order to receive maximum sunlight.

Aspect is an interval scale of measurement and is defined as a scale with equal intervals but with no true zero point. An example of a special type of interval scale is a circular scale, where not only is there no true zero, but any designation of high or low values is arbitrary. For example with regard compass direction or aspect there is no physical justification for a direction of north to be designated 0° or 360° degrees, and 90° cannot be said to be “larger” direction than 60°. Statistical methods for describing data from circular distributions are relatively recent and are still

undergoing development. Either X^2 or G may be used to test the goodness of fit of theoretical to an observed circular distribution.

Table 8.7 shows that on flat slopes there are 3 times the number of archaeological sites than the proportion of the surveyed areas. On other slopes the proportion of surveyed areas are either more or less the same as the archaeological sites located in them, except for the west and south-west facing slopes. The west and the south-west aspects are by far the most surveyed slopes in the study area with contributions of 21.375 percent and 22.875 percent respectively. The west and south-west facing slopes happen to have most of the archaeological sites, 27.35 percent and 25.85 percent respectively.

Aspect	%Total Study Area	%Searched Area	%Sites
Flat	7.98	0.8	3.05
North	8.8	12.275	9.25
NE	7.2	10.175	6.75
East	7.98	6.375	4.95
SE	6.98	5.275	2.75
South	11.08	11.275	9.15
SW	19.18	22.875	25.85
West	20.36	21.375	27.35
NW	10.48	10.575	10.9

Table 8.7 Slope Directions and Percentage of Sites.

Even within only the surveyed part of the study area it seems that there are relatively more archaeological sites in the west and south-west aspect relative to the area covered by these slopes. The frequencies of observations for all the aspects and archaeological sites in the study area is given in Figure 8.3.

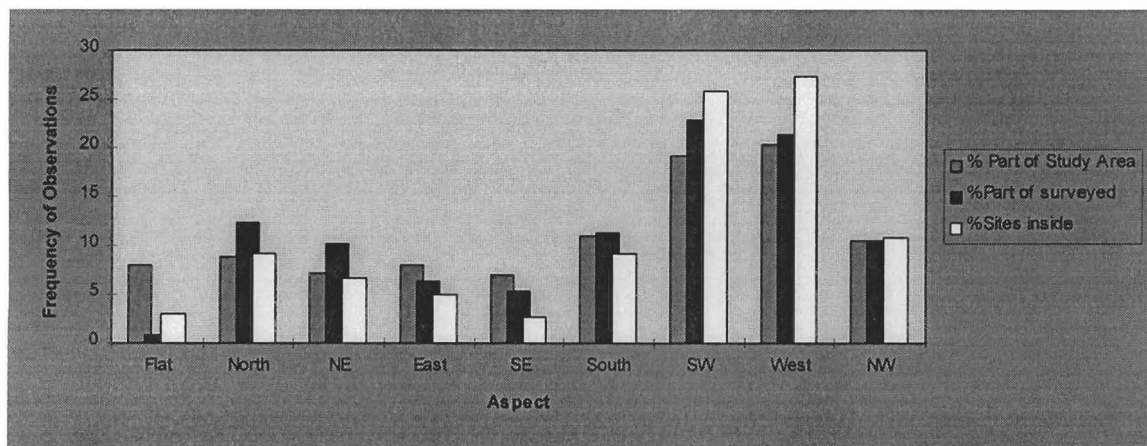


Figure 8.3 Histogram of Slope Directions and Sites.

The Chi-squared test will be used to determine whether or not it is possible that the distribution of archaeological sites with regard to the direction of slope is a matter of chance. If all nine slope directions were equally attractive to settlement then it would be reasonable to assume that we should find approximately the same density of settlement in each. The first step is to state the null hypothesis and its alternative :

H_0 : Archaeological sites are equally distributed in all aspects of surveyed areas.

H_A : Archaeological sites are not equally distributed in all aspects of surveyed areas.

Selected significance level : $\alpha = 0.05, 0.01, 0.001$ and $\nu = 9 - 1 = 8$. The results of the Chi-squared goodness of fit test are in Table 8.8.

	X^2_{calc}	$X^2_{0.05}$	$X^2_{0.01}$	$X^2_{0.001}$	
Sites vs. Area	254.84	15.5073	20.0902	26.125	Reject H_0
Sites vs. Survey	265.74	15.5073	20.0902	26.125	Reject H_0

Table 8.8 Results of Chi-Squared Test for Site Distribution.

It is clear that we have to reject the null hypothesis at all significance level in favour of the alternative, that archaeological sites are not distributed uniformly on the landscape. Some aspects have significantly more archaeological sites located in then

relative to the proportion that has been surveyed. The different archaeological potentials for the various slope directions are given in Table 8.9.

Aspect	Potential	Weight
Flat	Very High	5
North	Low	2
NE	Low	2
East	Low	2
SE	Low	2
South	Low	2
SW	High	4
West	High	4
NW	Medium	3

Table 8.9 Archaeological Potential for Slope Directions.

According to the figures in Table 8.9 flat slopes have the highest archaeological potential followed by west and south-west facing slopes. That is to be expected because these are the areas that probably received optimum sunlight, and if we assume that prehistoric people were rational being that is what one would expect. North-west facing slopes are next with an archaeological potential weight of 3, and the rest of the slopes have a weight of 2.

Slope

Slope is defined as the rate of maximum change in *z-values* from each cell of the Digital Elevation Model (Burrough 1986). Slope can influence human settlement in two ways. First, on steep slopes - dramatic changes in *z-values* over a short distance - people are not likely to build houses or set a campsite. Secondly, together with aspect slope determines the amount of solar radiation on the terrain - on the north aspect the steeper slopes receive more energy - an important consideration for prehistoric people.

Table 8.10 shows the distribution of archaeological sites and their corresponding slope values. According to Table 8.10, 39.1 percent of the archaeological sites are located in a landscape with slope values between 59.083° and 79.39° - which form 47.7 percent of the surveyed area.

Slope(in °)	%Total Study Area	%Searched Area	%Sites
< 18.468	5.06	3.3	7.1
18.468 – 38.775	11.6	8.9	9.5
38.775 – 59.083	22.9	17.5	19.7
59.083 – 79.39	48.24	47.7	39.1
>= 79.39	12.2	22.6	24.6

Table 8.10 Slope Indices and Percentage of Sites.

Figure 8.4 shows the cumulative percentage curve for the distribution of archaeological sites on various slopes of the study area. Looking at the figure suggest that archaeological sites are more or less uniformly distributed.

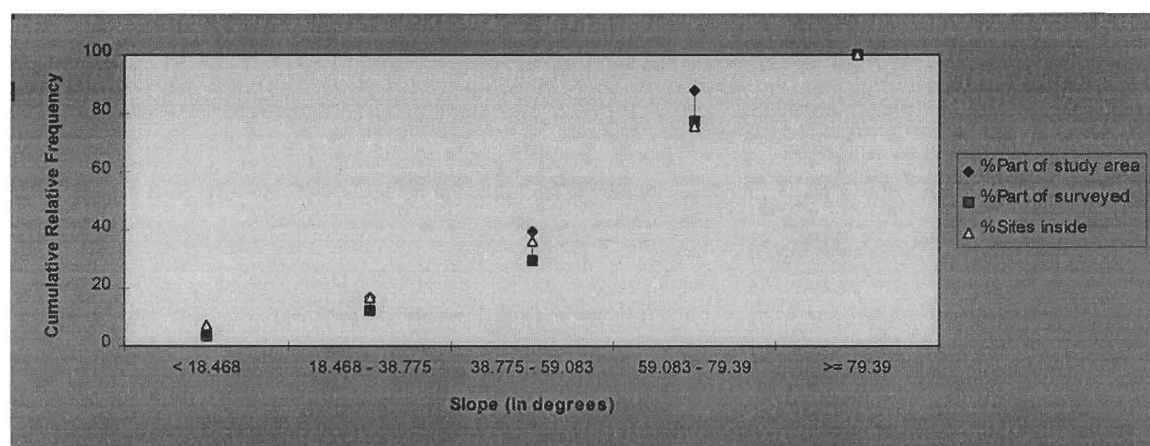


Figure 8.4 Cumulative Frequency Curve of Slope Indices.

Although slope is also a special type of interval scale in a circular scale it is different from aspect because the measurement scale is only a portion of a circle - constrained to a range of 0° to 90°. Such data may be treated as ratio data measured on a linear scale, hence the use of Kolmogorov-Smirnov Goodness of Fit test.

The null hypothesis for the Kolmogorov-Smirnov test is that archaeological sites are uniformly distributed throughout the various slopes of the landscape. The alternative hypothesis is that the archaeological sites are not uniformly distributed on the different slopes. The results of the test are given in Table 8.11 for the significance levels $p = 0.05$, 0.01 , and 0.001 . The Kolmogorov-Smirnov test indicate that archaeological sites are not uniformly distributed on the landscape. Some slopes have significantly more archaeological sites relative to the portion of the surveyed area that falls within these zones.

	$D_{max\ obs}$	$p = 0.05$	$P = 0.01$	$p = 0.001$	
Sites vs. Area	0.124	0.02933	0.03515	0.042102	Reject H_0
Sites vs. Survey	0.066	0.02933	0.03515	0.042102	Reject H_0

Table 8.11 Kolmogorov-Smirnov Results for Sites Distribution.

The results of the Kolmogorov-Smirnov test are such that the null hypothesis is rejected (Table 8.11). The bulk of the surveyed portion in the study area has a slope index that falls between $59.083^\circ - 79.39^\circ$ - almost half the surveyed area (Table 8.10). With regard the surveyed area Table 8.10 show that for the areas with a slope index less than or equal to 59.083° there are more archaeological sites relative to the portion of the surveyed areas made by these areas.

Slope(in $^\circ$)	Potential	Weight
< 18.468	Very High	5
18.468 – 38.775	Medium	3
38.775 – 59.083	High	4
59.083 – 79.39	Low	2
≥ 79.39	Medium	3

Table 8.12 Archaeological Potential for Slope Indices.

Table 8.12 shows the archaeological potential for the different slopes in the surveyed area. Areas with slopes values less than 18.468° and between 38.775° and 59.083° have ‘very high’ to ‘high’ archaeological potential compared with the rest which have ‘medium’ to ‘low’ archaeological potential.

Rainfall

Climate is the principal dynamic component and independent variable shaping both vegetation and soil (Akin 1991), hence human development. Rainfall, as proxy variable for climate in this project, is likely to have played an important role in settlement decision of prehistoric people. One might expect archaeological sites densities to drop with rainfall. An ideal situation would have been to use all climatic variable - light, temperature, and moisture in the broad sense - because they operate in combination rather than in isolation.

Table 8.13 indicate that 50.88 percent of the archaeological sites are located in areas that receive between 101 and 200 mm of rainfall per annum, and that only 44.88 percent of the surveyed area receive this amount of rainfall. In addition, only 35.49 percent of the whole study area receive this amount of rainfall. Furthermore, 25.08 percent of archaeological sites are located in areas that receive less or equal to 100 mm. of rainfall per annum, and that only 15.78 percent of the surveyed areas receive this amount of rainfall.

Rainfall(in mm)	%Part of Study Area	%Part of surveyed	%Sites within
<= 100	30.87	15.78	25.08
100 – 200	35.49	44.888	50.88
200 – 300	12.18	31.692	19.52
300 – 400	10.9	5.58	2.82
>= 400	10.56	2.06	1.7

Table 8.13 Annual Precipitation and Percentage of Sites.

Figure 8.5 shows the cumulative percentage curve for the distribution of archaeological sites in the different rainfall sector.

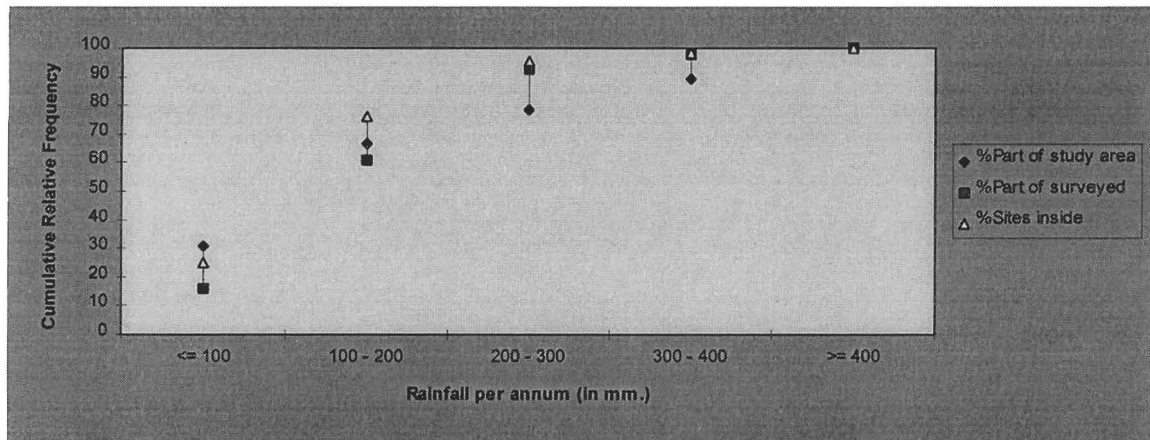


Figure 8.5 Cumulative Frequency Curve of Annual Precipitation.

The Kolmogorov-Smirnov test will be used to determine whether the null hypothesis is valid or not. The null hypothesis is that archaeological sites are uniformly distributed in all rainfall sectors of the surveyed areas, and the alternative is that they are not distributed uniformly. The results of the Kolmogorov-Smirnov test are outlined in Table 8.14.

	$D_{max\ obs}$	$p = 0.05$	$p = 0.01$	$p = 0.001$	
Sites vs. Area	0.1694	0.02933	0.03515	0.042102	Reject H_0
Sites vs. Survey	0.15292	0.02933	0.03515	0.042102	Reject H_0

Table 8.14 Kolmogorov-Smirnov Test for Site Distribution.

The Kolmogorov-Smirnov Goodness of Fit results are outlined in Table 8.14. The null hypothesis that archaeological sites are distributed uniformly in the study area is rejected at all significance levels. The alternative hypothesis that archaeological sites are not distributed uniformly, is accepted. Some areas because of the amount of

annual precipitation they received were more attractive to prehistoric settlement than others.

Rainfall(in mm)	Potential	Weight
<= 100	Very High	5
100 – 200	High	4
200 – 300	Low	2
300 – 400	Low	2
>= 400	Low	2

Table 8.15 Archaeological Potential of Different Rainfall Zones.

According to Table 8.15 areas with annual rainfall less than or equal to 100 mm have a ‘very high’ archaeological potential. For areas with between 100 mm. and 200 mm. of annual rainfall the archaeological potential is ‘high’ compared with areas that have more 200 mm. of rainfall per annum, which have a ‘low’ potential for archaeological sites.

Vegetation

At present 2144 archaeological sites fell within the vegetation data sets. Of the six Veld types in the study area, the archaeological sites were located only within three, the Strandveld of the West Coast, Coastal Renosterveld and Succulent Karoo. These Veld types constitute as much as 81.8 percent of the study area. At present there are no archaeological sites located in the remaining 18.2 percent which is made up of Coastal Macchia, Macchia (fynbos), and Namaqualand Brokenveld.

Table 8.16, tabulate the distribution of archaeological sites amongst the various vegetation types. The table indicate that 94.9 percent of archaeological sites are located in the Strandveld vegetation, 4.4 percent in the Coastal Renosterveld, and 0.8 percent in the Succulent Karoo.

Vegetation Type	%Part of study- area	%Part of Surveyed	%Sites inside
Succulent Karoo	33.8	2.07	0.6
Namaqualand	0.2	0	0
Strandveld of West coast	42.1	88.53	94.9
Coastal Renosterveid	5.9	9.4	4.4
Coastal Macchia	14.1	0	0
Macchia(fynbos)	0.04	0	0

Table 8.16 Vegetation Types and Percentage of Sites.

Figure 8.6 and Table 8.16 indicate that there are slightly more archaeological sites located in the Strandveld vegetation relative to the proportion of the surveyed area that is covered this particular type. When compared with the proportion of the study area that is covered by the Strandveld vegetation the ratio of sites to proportion of the study area is 2 : 1. The other two vegetation type - Coastal Renosterveld and Succulent Karoo form 9.4 percent and 2.07 percent of the surveyed area and have 4.4 percent and 0.6 percent of archaeological sites respectively. There relatively fewer sites in the Coastal Renosterveld and Succulent Karoo relative to proportion of the surveyed area covered by these vegetation types.

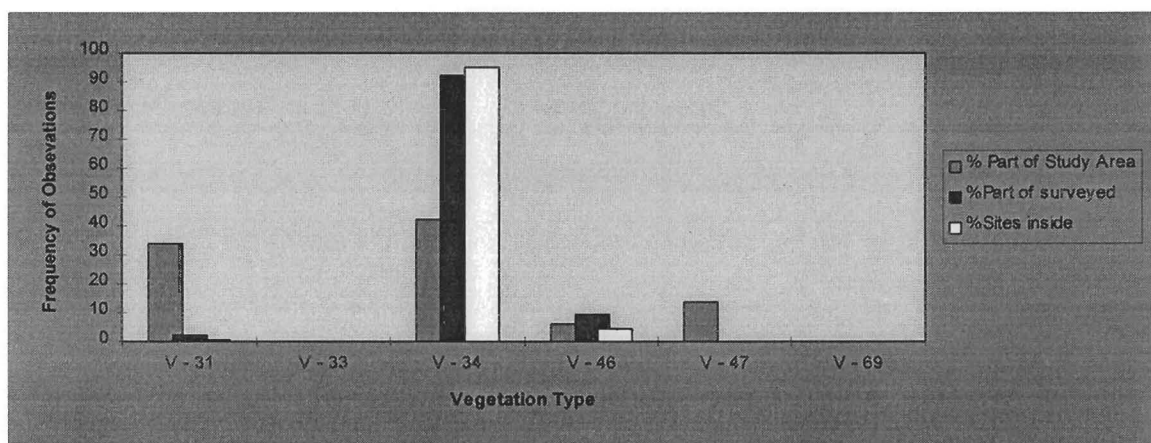


Figure 8.6 Histogram of Vegetation Types and Archaeological Sites.

The Chi- squared test will be used to determine whether or not archaeological sites were distributed uniformly over all the vegetation types. The null hypothesis and its alternative :

H_0 : Archaeological sites are distributed uniformly on the vegetation types.

H_A : Archaeological sites are not distributed uniformly on the vegetation types.

The test results are given in Table 8.17 at significance levels 0.05, 0.01, and 0.001 with 5 degrees of freedom.

	X^2_{calc}	$X^2_{0.05}$	$X^2_{0.01}$	$X^2_{0.001}$	
Sites vs. Area	2434.544	11.0705	15.0863	20.515	Reject H_0
Sites vs. Survey	89.2296	15.5073	20.0902	26.125	Reject H_0

Table 8.17 Chi-Squared Test Results for Sites Distribution.

According to Table 8.17 the null hypothesis is rejected at all significance level. Then the alternative hypothesis - archaeological sites are not distributed uniformly on the vegetation types - is taken as being true. This means that at some vegetation types there are significantly more archaeological sites relative to the surveyed proportion of the study area that forms part of that vegetation.

Vegetation Type	Potential	Weight
Succulent Karoo	Very Low	1
Namaqualand		
Strandveld of West Coast	Medium	3
Coastal Renosterveld	Very Low	1
Coastal Macchia		
Macchia(fynbos)		

Table 8.18 Archaeological Potential of Vegetation Types.

Areas in the study are with Strandveld of the West Coast vegetation have a ‘medium’ archaeological potential (see Table 8.18). This is followed by areas with Succulent Karoo and Coastal Renosterveld which have a ‘very low’ archaeological potential. The rest of the vegetation types in the study area not much can be said about because there are no archaeological sites located in them and they have not been surveyed.

Geology

A total of 2103 archaeological sites fell inside the geological data set. These geological groups or formations are Cape Supergroup, Gariep Complex, Klipheuwel Formation, Namaqualand Metamorphic Province, Quaternary Formation, Tertiary Formation, and Intrusive Rocks. There are no archaeological sites located in the Malmesbury Group and Vanrhynsdorp Group at present.

Geology	%Part of Study area	%Part Surveyed	%Sites inside
Cape Supergroup	4.06	15.3	14.3
Gariep Complex	3.27	1.37	8.5
Klipheuwel Formation	0.19	0.75	0.6
Namaqualand	0.78	0.39	5.3
Quaternary Formations	71.2	59.39	49.2
Tertiary Formations	4.5	6.48	3.2
Malmesbury Group	2.9	0.09	0
Vanrhynsdorp Group	0.3	0	0
Intrusive Rocks	8.7	16.23	18.7

Table 8.19 Geological Formations and Percentage of Sites.

Table 8.19 is the tabulation of the proportions of the various geological formations and groups, and the proportions of known archaeological sites found within them. Almost 50 percent of all known archaeological sites are located within a single geological formation - Quaternary Formations - which form 71.2 percent of the study area and 59.39 percent of the surveyed area. The Intrusive Rocks and Cape

Supergroup have 18.7 percent and 14.3 percent of the known archaeological sites and form 8.7 percent and 4.06 percent of the study area and 15.68 percent and 14.7 percent of surveyed areas respectively.

Figure 8.7 is a histogram for the distribution of archaeological sites in the various geological formations and shows that there are more archaeological sites are located in the Gariiep Complex, Namaqualand Metamorphic Province and Intrusive Rocks, relative to the proportion of the surveyed area that is covered by these geological formations.

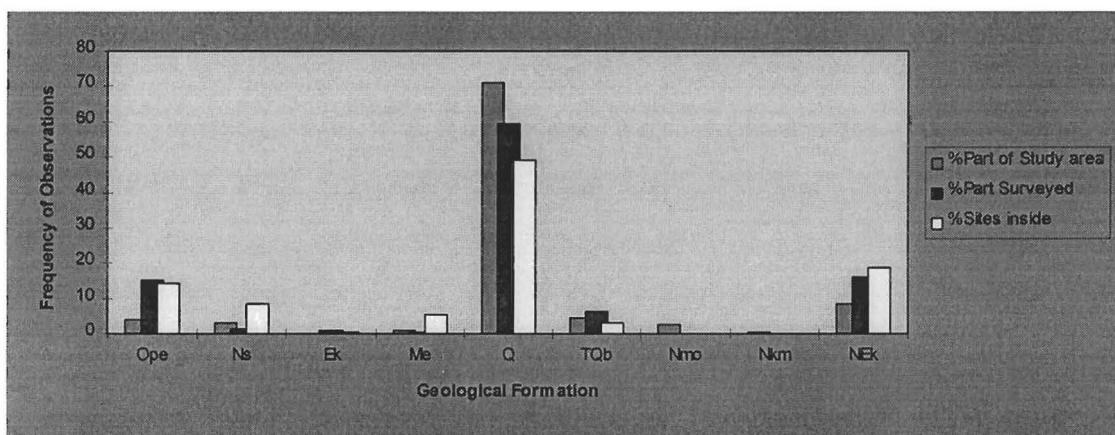


Figure 8.7 Histogram of Geological Types and Archaeological Sites.

The Chi-squared test will be used to determine whether archaeological sites are uniformly distributed on all the geological formations, which is the null hypothesis. The alternative hypothesis will be that archaeological sites are not distributed uniformly on all the geological formations.

	X^2_{calc}	$X^2_{0.05}$	$X^2_{0.01}$	$X^2_{0.001}$	
Sites vs. Area	1529.587	15.5073	20.0902	26.125	Reject H_0
Sites vs. Survey	2197.961	15.5073	20.0902	26.125	Reject H_0

Table 8.20 Chi-Squared Test Results of Site Distribution.

According to Table 8.20 the null hypothesis is rejected in favour of the alternative hypothesis. This means that archaeological sites are not uniformly distributed on the landscape, and that some geological formations have relatively more sites than the area surveyed. The archaeological potential for the various geological formations and groups is given below in Table 8.21.

Geology	Potential	Weight
Cape Supergroup	Medium	3
Gariiep Complex	Very High	5
Klipheuwel Formation	Low	2
Namaqualand	Very High	5
Quaternary Formations	Low	2
Tertiary Formations	Very Low	1
Malmesbury Group	Very Low	1
Vanrhynsdorp Group		0
Intrusive Rocks	High	4

Table 8.21 Archaeological Potential of Different Geological Types.

The Gariiep Complex and the Namaqualand geological formations have the most archaeological potential in the study area and they are given a weight of 5. The next geological formations with a ‘high’ to ‘medium’ archaeological potential are the Intrusive Rocks and the Cape Supergroup. The rest of the study area have ‘low’ to ‘very low’ potential, with the Vanrhynsdorp Group not given a weight because no archaeological sites were found and it has not been surveyed.

Synthesis

The next step is to create an Archaeological Sensitivity Model - a composite of all the map layers that were deemed to have attracted human settlement in the past. The sensitivity model is created by beginning with a basic assumption that all the variables contribute equally to the determination of site location potential. Calculating high,

medium or low potential areas is simply a process of determining the number of variables that converge in a given location. Areas where the highest number of variables occur can be labelled 'high' while areas where the lowest number of variables occur can be labelled 'low'. The use of the terms 'high', 'medium', and 'low', is highly subjective. In addition, the assumption that all variables contribute equally to the determination of the predictive model does not really reflect the complexity of human land use decision-making.

When assigning weights to the various categories within each environmental coverage, 'high' to 'very high' values have been given to the following :

- Areas between 0 and 2 kilometers from rocky shoreline;
- Areas that are ≤ 50 meters or ≥ 200 meters above sea level;
- Flat, south-west and west facing slopes;
- Areas with slope ≤ 18.468 and between 38.775 and 59.083;
- Areas that receive ≤ 200 mm. of precipitation per year;
- Intrusive Rocks, Gariiep Complex and Namaqualand geological formations.

'Medium' category weights were assigned to the following :

- North-West facing slopes;
- Slopes with values between 18.468 and 38.775, and greater than or equal to 79.39;
- Strandveld of the West Coast;
- Cape Supergroup.

'Low' to 'very low' category weights for the following :

- Areas more than 2 kilometers from rocky shoreline;
- Between 50 and 200 meters above sea level;
- North, north-east, East, south-east, and South facing slopes;
- Slopes with values between 59.083 and 79.39;
- More than 200 mm. annual precipitation;
- Klipheuwel, Tertiary and Quaternary Formations, and Malmesbury Group;
- Succulent Karoo and Coastal Renosterveld.

The Archaeological Sensitivity Model is created by adding all the different weighted environmental overlays using the Map Calculation capabilities of the Spatial Analyst

of Arcview. The model is given in Map 15 (in Appendix C) and the results are tabulated below in Table 8.22. The standard deviation was used together with the mean to break-up the study area into categories ‘low’, ‘medium’, and ‘high’. For example areas which are > 1 Standard Deviation have a ‘high’ archaeological potential, between 1 and -1 Standard Deviation have a ‘medium’ archaeological potential, and < -1 Standard Deviation have ‘low’ archaeological potential.

Potential	%Part of Study Area	%Sites
Low	19.669	8.58
Medium	61.768	37.126
High	18.56	54.289

Table 8.22 Archaeological Potential and Percentage Part of the Study Area.

According to Figure 8.8 and Table 8.22, 18.56 percent of the study area has been flagged as a high archaeological sensitivity zone. There are 54.289 percent of archaeological sites located in the high archaeological sensitivity zone. The medium sensitivity zone covers 61.768 percent of the study area and there are 37.126 percent of the archaeological sites. There are only 8.58 archaeological sites located in the low archaeological sensitivity zones, and 19.669 percent of the study area form these zones.

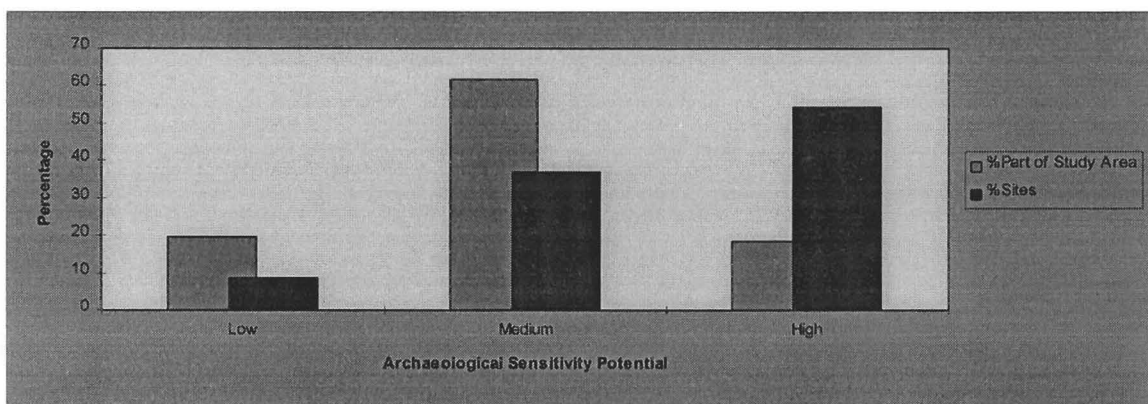


Figure 8.8 Histogram of Archaeological Potential.

The next step is evaluate or assess the performance of the Archaeological Sensitivity Model by determining its success and effectiveness. According to Table 8.22, 54.289 percent of archaeological sites are located in high archaeological sensitivity zones. That is equivalent to saying that the success rate of the model is 54.289 percent. The 45.711 percent error must be expected and allowed because no model is perfect. In most models errors are largely due to the fact that locational models will tend to be biased toward the archaeological pattern of sites on or near the surface and those of recent age. The use of a multi-dimensional model that uses paleoenvironments will help to mitigate this factor.

In addition to success, a good predictive model needs to be effective for it to be of any use as a research and a management tool. Effectiveness means that our model with a success rate of 54.289 percent, then it must map substantially less than 54.289 percent of the study area to 'high' archaeological sensitivity zones. Table 8.22 shows that only 18.56 percent of the study area has been flagged as a 'high' archaeological potential zone.

The main criticism of this model is the fact that the predictive ability of the environmental variables of is based on archaeological site density. Two environmental variables can have the same number of archaeological sites, but with variable x having a large area than variable y , and they will have different sensitivity categories in terms of the model. For example with regard to geology, there are 49.2 percent of the known sites located in areas that have Quaternary Formations, and only 8.5 percent in areas with Gariep Complex (see Table 8.19). According to our model the Gariep Complex is flagged as a 'very high' potential area while the Quaternary Formation is flagged as 'low' archaeological potential area (see Table 8.21). For management purposes that does not make sense. For management purposes it makes sense to have areas with Quaternary Formations flagged 'very high', and areas with the Gariep Complex flagged 'low'.

A different approach to what has been done will be to use the absolute number of archaeological sites as a guide in determining 'high', 'medium' and 'low'

archaeological potential areas, instead of density. For example an area in each of the environmental variables which has ≥ 30 percent of the archaeological sites is flagged 'high', ≥ 10 percent is flagged medium, and < 10 percent is flagged 'low'.

'High' category weights were assigned to the following :

- Areas within 1 kilometre of the rocky shoreline;
- Areas that are ≤ 50 meters above sea level;
- Areas with slope values between 59.083° and 79.39° ;
- Areas that receive between 100 mm. and 200 mm. rainfall a year;
- Strandveld of the West Coast;
- Quaternary Formations.

'Medium' category weights were assigned to the following :

- Areas between 1 and 2, and 5 and 20 kilometers from the rocky shoreline;
- Areas that are between 50 meters and 200 meters above sea level;
- South-west, west and north-west facing slopes;
- Areas with slope values between 38.775° and 59.083° , and $\geq 79.39^\circ$;
- Areas that receive ≤ 100 mm., and between 200 and 300 mm. rainfall a year;
- Cape Supergroup, and Intrusive Rocks.

'Low' category weights were assigned to the following :

- Areas between 2 and 5 kilometers, and ≥ 20 kilometers from rocky shoreline;
- Areas ≥ 200 meters above sea level;
- Flat, north, north-east, east, south-east and south facing slopes;
- Areas with slopes values $\leq 38.775^\circ$;
- Areas that receive more than 300 mm. of rainfall a year;
- Succulent Karoo and Coastal Renosterveld;
- Gariiep Complex, Klipheuwel Formation, Namaqualand and Tertiary Formations.

A sensitivity model is created which is a composite of all the map layers. Once again the assumption that all environmental variables contribute equally to the determination of site location potential is maintained. The sensitivity model is given in Map 15a (in Appendix C) and tabulated in Table 8.23.

Potential	%Total Study Area	%Sites
Low	9.2	7.3
Medium	74.7	57.5
High	16.05	35.2

Table 8.23 Archaeological Potential and Percentage of Study Area.

According to Table 8.23 and Figure 8.9, 16.05 percent of the study area has been flagged as a ‘high’ archaeological potential zone by the sensitivity model. This is less than the area flagged as a ‘high’ archaeological potential zone when using density (see Table 8.22). Furthermore in Map15a, only 35.2 percent of archaeological sites are located in ‘high’ archaeological potential zone, while for Map 15 the corresponding value was 54.289 percent (see Table 8.22). So, it would seem that our initial sensitivity model based on archaeological site density works better.

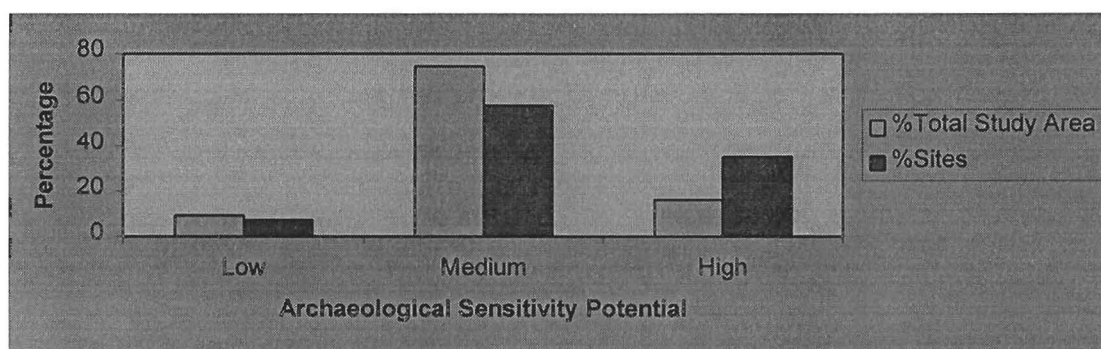


Figure 8.9 Histogram of Archaeological Potential. Figure 8.8

Essentially the major difference between the two model, Model I and Model Ia is that the latter is concerned about management issues and the former is a research tool developed to facilitates management. Intellectually the two – research and

management – have been thought as two distinct entities, whilst in fact they are interconnected.

Archaeological Sensitivity Model II

Sometimes the intention is not to develop an archaeological sensitivity map that encompasses all cultural resources. The intention might be to develop a model for rock art sites and it is obvious that the environmental variables determining the locations of a Later Stone Age Rock Art site may be quite different from those affecting a Later Stone Age shell midden. In addition, this project has been designed to facilitate heritage management, and the effective management of a painted site involves procedures that may not be required by other archaeological sites. Furthermore greater resolution may be obtained if archaeological sites are divided into temporal and functional types.

How does the model perform when the archaeological sites are divided into functional types? Table 8.24 shows the results of the Archaeological Sensitivity Model with the different site types, shell middens, deflation hollows, open sites, and cave sites. The latter - cave sites - include caves, rock shelters, and overhangs.

Potential	Shell Middens	Deflation Hollow	Open Sites	Caves
Low	17.84	4.44	10.43	3.75
Medium	20.64	27.97	33.81	75.5
High	66.33	67.6	55.76	20.75

Table 8.24 Distribution of Site Types in the Archaeological Sensitivity Model.

According to Table 8.24 66.33 percent, 67.6 percent and 55.76 percent of Shell Middens, Deflation Hollows, and Open Sites are located in areas that are flagged as ‘high’ potential for the presence of archaeological sites. On the other hand only 20.75 percent of cave sites are located in ‘high’ archaeological potential areas. The results of Table 8.24 are represented graphically in Figure 8.9 below.

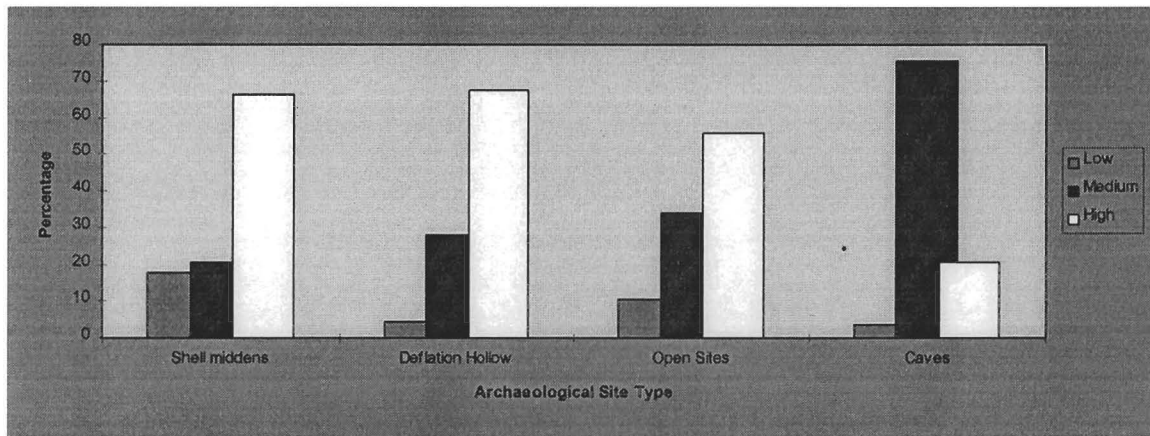


Figure 8.10 Histogram of Site Types in the Archaeological Sensitivity Model.

Figure 8.10 and Table 8.24 seem to suggest that the performance of the sensitivity model is not that effective in identifying areas where caves sites are likely to be located. A possible reason might be the fact that the formation and the location of caves is a complex phenomena that is dependent on geological formation and other factors that are quite distinct from those that influence the location of shell middens, deflation hollows, and open sites.

Dividing archaeological sites into functional types when developing an Archaeological Sensitivity Model will achieve two new objectives. First it will result in a sensitivity model for specific archaeological sites that are of a particular functional type, in this case cave sites. Secondly, because all the rock art in the study area is located in these site types, the sensitivity model will be sufficient to predict the occurrence of art. The distribution of caves sites in the study area will be investigated for five environmental variables. They are the coastline, topography, slope, aspect, and geology. The choice of the five variables was done intuitively. Based on local

knowledge of the study area the topography is hardly suitable for cave sites near the coastline, one is unlikely to find cave sites on flat slopes and aspect, and not all geological formations are suitable for the formation of caves.

Coastline

The percentages of cave sites in the various sample strips away from the coastline are given in Table 8.25. The striking thing about Table 8.25 is that 60 percent of all cave sites are located at distance between 10 kilometers and 20 kilometers from the coastline, and area that forms only 31.926 percent of the surveyed areas.

Distance(in km)	%Part of study area	%Part of surveyed	%Caves inside
0 – 1	5.2	15.32	7
1 – 2	4.4	10.914	1
2 – 3	4.3	7.14	7.25
3 – 5	8.4	11.24	9.75
5 – 10	20.9	23.46	15
10 – 20	56.8	31.926	60

Table 8.25 Distribution of Caves Along the Coastline.

The results of the Kolmogorov-Smirnov goodness of fit test in order to determine if cave sites are distributed uniformly in all the sample strips are given in Table 8.26. The null hypothesis that cave sites are uniformly distributed is rejected when comparing the observed cave sites with the expected sites based on the surveyed areas at all significance levels. The null hypothesis is accepted when the expected number of cave sites is based on the entire study area. In our case what is relevant is the expected value based on the surveyed, hence the null hypothesis is rejected.

	$D_{\max_{\text{obs}}}$	$p = 0.05$	$p = 0.01$	$p = 0.001$	
Sites vs. Area	0.0665	0.06790	0.08138	0.097474	Accept H_0
Sites vs. Survey	0.28074	0.06790	0.08138	0.097474	Reject H_0

Table 8.26 Kolmogorov-Smirnov Results of Cave Distribution Along the Coast.

Table 8.27 shows the archaeological potential and weights for the presence of cave sites in all the sample strips around the coastline. The area between 10 kilometres and 20 kilometres from the coastline has by far the highest potential for cave sites. The rest of the sample strips have either ‘low’ or ‘very low’ archaeological potential, except for the area between 2 and 3 kilometers off the coastline, which has a ‘medium’ potential.

Distance(in km)	Potential	Weight
0 – 1	Very Low	1
1 – 2	Very Low	1
2 – 3	Medium	3
3 – 5	Low	2
5 – 10	Low	2
10 – 20	Very High	5

Table 8.27 Archaeological Potential of Sample Strips Along the Coast.

Elevation

The percentages of cave sites in the various elevation zones are given in Table 8.28. There are 49 percent cave sites located in areas that are less than or equal to 50 meters above sea-level, 38.75 percent in areas between 50 and 100 meters above sea-level, and 12.25 percent in areas between 100 and 200 meters above sea level. There are no cave sites located in areas that are 200 meters above sea level.

DEM(meters)	Area Study Area	%Part of surveyed	%Cave within
<= 50	22.57	40.05	49
50 – 100	21.82	24.79	38.75
100 – 200	41.19	32.904	12.25
200 – 300	11.89	2.052	0
>= 300	2.53	0.204	0

Table 8.28 Distribution of Caves in Different Elevation Levels.

The results of the Kolmogorov-Smirnov goodness of fit test to determine if cave sites are uniformly distributed in all the elevation ranges on the landscape are given in Table 8.29. The null hypothesis - cave sites are distributed uniformly in all elevation ranges - is rejected at all significance levels.

	$D_{max\ obs}$	$p = 0.05$	$p = 0.01$	$p = 0.001$	
Sites vs. Area	0.7333	0.06790	0.08138	0.097474	Reject H_0
Sites vs. Survey	0.85494	0.06790	0.08138	0.097474	Reject H_0

Table 8.29 Kolmogorov-Smirnov Results of Caves in Elevation Zones.

The potential for the presence of cave sites in the study area is given in Table 8.30. For areas that are less or equal to 50 meters above sea-level, and between 50 and 100 meters above sea-level, the potential for the presence of cave sites is ‘high’ and ‘very high’ respectively. For the rest of the other elevation zones in the study area the potential is ‘very low’.

DEM(meters)	Potential	Weight
<= 50	High	4
50 – 100	Very High	5
100 – 200	Very Low	1
200 – 300	Very Low	1
>= 300	Very Low	1

Table 8.30 Archaeological Potential of Different Elevation Levels.

Aspect

The distribution of cave sites in the various aspects of the study area is given in Table 8.31. There are cave sites located on all the aspects except for the flat aspect. The only aspects where the percentage of cave sites is more than the percentage of the area surveyed are the east, south-east, west and north-west facing slopes. For the rest of the slopes there are less cave sites than the percentage of surveyed area.

Aspect	% Part of Study Area	%Part of surveyed	%Caves within
Flat	7.98	0.8	0
North	8.8	12.275	7.75
NE	7.2	10.175	7.75
East	7.98	6.375	16.5
SE	6.98	5.275	8.25
South	11.08	11.275	3.25
SW	19.18	22.875	6.5
West	20.36	21.375	23.75
NW	10.48	10.575	14

Table 8.31 Distribution of Caves in Different Aspects.

The Chi-squared test is used to determine if the distribution of cave sites in the various aspects is uniform, and the results are given in Table 8.32. The null hypothesis, that cave sites are distributed uniformly is rejected at all significance levels.

	X^2_{calc}	$X^2_{0.05}$	$X^2_{0.01}$	$X^2_{0.001}$	
Sites vs. Area	1999.887	15.5073	20.0902	26.125	Reject H_0
Sites vs. Survey	158.4469	15.5073	20.0902	26.125	Reject H_0

Table 8.32 Chi-Squared Test Results of Cave Distribution.

The potential for the various aspects in the study area are given in Table 8.33. For the flat, south, and south-west aspects the potential for the presence of cave sites in the study area is ‘very low’, and for the north and north-east aspects the potential is ‘low’. For the west and north-west, and the east and south-east aspect the potential for the presence of cave sites is ‘high’ and ‘very high’ respectively.

Aspect	Potential	Weight
Flat	Very Low	1
North	Low	2
NE	Low	2
East	Very High	5
SE	Very High	5
South	Very Low	1
SW	Very Low	1
West	High	4
NW	High	4

Table 8.33 Archaeological Potential of Different Aspects.

Slope

The distribution of cave sites in the various slopes in the study area is given in Table 8.34. According to Table 8.34 the vast majority of cave sites are located in areas with a slope index greater or equal to 79.39° - 83 percent, an area that form only 22.6 percent of the surveyed areas.

Slope(in °)	% Part of study area	%Part of surveyed	% Caves within
< 18.468	5.06	3.3	0.25
18.468 – 38.775	11.6	8.9	0.75
38.775 – 59.083	22.9	17.5	4
59.083 – 79.39	48.24	47.7	12
>= 79.39	12.2	22.6	83

Table 8.34 Distribution of Caves Along Slopes of Different Indices.

The results of the Kolmogorov-Smirnov goodness of fit test to determine whether to accept the null hypothesis that cave sites are distributed uniformly on all slopes are given in Table 8.35. The null hypothesis is rejected at all significance level in favour of the alternative hypothesis, that cave sites are not distributed uniformly. Some slopes in the landscape were more attractive or suitable for prehistoric settlement.

	Dmax _{obs}	P = 0.05	p = 0.01	p = 0.001	
Sites vs. Area	0.708	0.06790	0.08138	0.097474	Reject H_0
Sites vs. Survey	0.604	0.06790	0.08138	0.097474	Reject H_0

Table 8.35 Kolmogorov_Smirnov Test Results of Cave Distribution.

The potentials for the presence of cave sites in the various slopes of the study area are given in Table 8.36. Areas with a slope index greater than or equal to 79.39 are by far the most suitable for cave sites. The rest of the slopes had a 'very low' potential.

Slope(in °)	Potential	Weight
< 18.468	Very Low	1
18.468 – 38.775	Very Low	1
38.775 – 59.083	Very Low	1
59.083 – 79.39	Very Low	1
>= 79.39	Very high	5

Table 8.36 Archaeological Potential of Different Slopes.

Geology

Table 8.37 shows the distribution of cave sites in the various geological formations that form the study area. An overwhelming proportion of the cave sites - 60.75 percent - are located in the Cape Supergroup geology, which forms only 15.3 percent of the surveyed area. The Klipheuwel Formation only forms 0.75 percent of the surveyed area, but has 3.25 percent of the cave sites, which means that there are 4.3 times more sites in this formation than was expected.

Geology	%Part of Study area	%Part Surveyed	%Cave inside
Cape Supergroup	4.06	15.3	60.75
Gariiep Complex	3.27	1.37	0
Klipheuwel Formation	0.19	0.75	3.25
Namaqualand	0.78	0.39	0.5
Quaternary Formations	71.2	59.39	32.75
Tertiary Formations	4.5	6.48	0.25
Malmesbury Group	2.9	0.09	0
Vanrhynsdorp Group	0.3	0	0
Intrusive Rocks	8.7	16.23	1.25

Table 8.37 Distribution of Caves in Geological Formations.

The Chi-squared goodness of fit test is used to determine if the cave sites are distributed uniformly on all the geological formations. The null hypothesis is that cave sites are distributed uniformly, and the alternative hypothesis is that they are not distributed uniformly. The results for the Chi-squared test are given in Table 8.38, and the null hypothesis is rejected at all significance levels for the alternative hypothesis.

	X^2_{calc}	$X^2_{0.05}$	$X^2_{0.01}$	$X^2_{0.001}$	
Sites vs. Area	3513.103	15.5073	20.0902	26.125	Reject H_0
Sites vs. Survey	706.4126	15.5073	20.0902	26.125	Reject H_0

Table 8.38 Chi-Squared Test Results of Cave Distribution.

The potentials for the presence of cave sites in the various geological formations in the study area are given in Table 8.39. Two geological formations stand out, the Cape Supergroup and the Klipheuwel Formation with ‘very high’ potential followed by the Namaqualand with a ‘high’ potential. The rest of the geological formations have ‘low’ to ‘very low’ potential for the presence of cave sites.

Geology	Potential	Weight
Cape Supergroup	Very High	5
Gariiep Complex	Very Low	1
Klipheuwel Formation	Very High	5
Namaqualand	High	4
Quaternary Formations	Low	2
Tertiary Formations	Very Low	1
Malmesbury Group	Very Low	1
Vanrhynsdorp Group		
Intrusive Rocks	Very Low	1

Table 8.39 Archaeological Potential of Different Geological Formations.

Synthesis

When assigning weights to the various categories within each environmental coverage, 'high' to 'very high' values have been given to the following :

- Areas that are ≤ 100 meters above sea level;
- Namaqualand, Cape Supergroup and Klipheuwel Formations;
- Slope values greater or equal to 79.39° ;
- East, south-east, west and north-west facing slopes;

Low to very low category weights were assigned to the following :

- Areas more than 100 metres above sea level;
- Flat, North, north-east, South, and South-West facing slopes;
- Slopes with values less than 79.39° ;
- Gariiep Complex, Quaternary and Tertiary formations, Malmesbury, and Intrusive Rocks.

The Archaeological Sensitivity Model for the presence of cave sites in the study area is given in Map 16 (in Appendix C) and outlined in Table 8.40.

Potential	%Part of Study Area	%Caves
Low	19.491	1.75
Medium	64.472	47.5
High	16.037	57.5

Table 8.40 Proportion of the Study Area With Their Archaeological Potential.

The results of Table 8.40 are represented graphically in Figure 8.11. According to Table 8.40, 57.5 percent of cave sites are located in the 'high' archaeological potential zone, and 16.037 percent of the study area is in this zone. It would seem that by doing a separate model specific to cave sites has worked, and is effective in identifying areas that are likely to have these functional type.

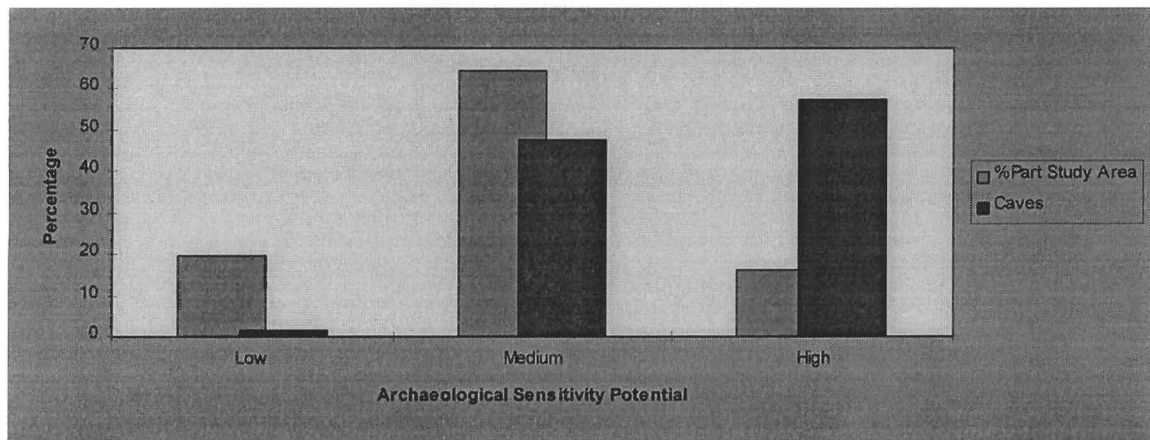


Figure 8.11 Histogram of Archaeological Sensitivity Model.

Summary

The modern concept of conservation - the wise maintenance and utilisation of the earth's resources - is not unique as one might think. In 1084 AD King William I of England ordered the preparation of the Domesday Book - an inventory of all the lands, forests fishing areas, agricultural areas, hunting preserves and productive resources of his kingdom - as the basis for making rational plans for the country's management and development (MacKinnon 1986). Today's concept is thus merely a combination of the two ancient principles namely : the need to plan resource management on the basis of an accurate inventory; and the need to take protective measures to ensure that resources do not become exhausted.

That is essentially what has been done here, and more. We have initially established an inventory of all the known cultural resources on the Cape West Coast. The inventory in itself has multiple purposes. First, the inventory is an important source of information about the archaeological resources in the study area. Secondly, the inventory is an important research tool for people wanting to know what archaeological research has uncovered on the Cape west coast, and direct them where to work. Last but not least, the inventory has made it possible to establish an Archaeological Sensitivity Model. The Archaeological Sensitivity Model is a tool that will facilitates a proactive approach in the management of archaeological resources. It

is a research tool that will alert developers about the possibility of archaeological resources being located on their property, so that they could be better prepared for the legal implications.

The Archaeological Sensitivity Model predicts areas of high, medium, and low sensitivity based on the relationships between known archaeological sites and certain environmental variables. It is envisaged that the model will be used in the field of Cultural Resource Management, but for a number of reasons probably need adequate testing before it can be used. First, some of the archaeological data was recorded from 1:50 000 mapsheets that were used by the field archaeologists. However, it has been noted by Kaplan (1993) that the level of detail that is in 1:50 000 mapsheets may not meet the needs of planners, who usually work with the 1:10 000 scale. Secondly, during the development of the Archaeological Sensitivity Model there was a lack of environmental variables at suitable scale, and that resulted in a fairly crude model. Lastly, it is necessary to test the model, because it is developed from existing non-probabilistic archaeological samples.

The next stage is the development of a multidimensional model. A separate model should be developed for each functional and temporal typology, and then the overall Archaeological Sensitivity Model being the combined result of the individual models. In addition to the development of a composite model, the model's potential will be enhanced by the incorporation of socio-cultural and ethnographic variables which have an environmental consequence. These additional steps will enhance the model's potential as a planning and management tool.

CHAPTER 9. MANAGEMENT STRATEGIES

Now that we have reviewed the archaeological resources that are located in the study area, the environment and context they are in and established an Archaeological Sensitivity Model, the next step is to look at various ways to manage the resource. Do we rely on traditional approaches - legislation and policing - or do we find creative ways to conserve the resource? It is the opinion of this researcher that we need something more than traditional approaches. We need to move away from the approach of looking at each site on its merits without any consideration of other archaeological sites, or other groups of sites and how a particular site fits in the whole scheme of things. Cultural Resource Managers need to look upon archaeological resources as systems, more akin to either ecological *systems* or *natural systems*. For example, we need to pay closer attention to relations between sites and look at the settlement arrangements of earlier people as systems rather than as isolated and distinct events.

This alternative approach does not disregard the importance of legislation and all the work that has been done in the past. There will still be scope to conserve 'charismatic' and rare sites where it is perceived to be necessary. The advantage of the new approach is that archaeologists will start to look at conservation in a holistic manner, and as a result cut down on the bias inherent in present approaches where only 'charismatic' sites are considered conservation-worthy.

The alternative approach would be to look at conservation techniques that are employed by natural scientists. Management techniques that attempt to conserve whole social systems and the biological or environmental processes. Instead of trying to conserve archaeological sites on singular basis, try to conserve whole cultural systems and the biological or environmental processes that maintained these systems. The result will be a 'patch' of land that can be referred to as 'archaeological reserves', in the same way that we define nature reserves.

The concept of 'archaeological reserves' is the same as that of 'cultural landscapes' which formed the framework of the 1972 UNESCO World Heritage Convention. 'Cultural landscapes' are "works of man or the combined works of nature and of man, and areas including archaeological sites which are of outstanding value from the historical, aesthetic, ethnological or anthropological point of view." (ICOMOS 1990).

Examples of 'cultural landscapes' that have been declared to date include Tikal in Guatemala, Kakadu National Park in Australia, Goreme and rock-art sites of Cappadocia. These include prehistoric rock-art sites, sacred mountains and exceptional geological features with important religious or secular settlements on them. The aim of declaring 'cultural landscapes' is to maintain harmonious significant landscapes which are characteristic of the harmonious interaction of people and land, while at the same time providing opportunities for public enjoyment through recreation and tourism within the normal life-styles and economic activity of these areas (Cleere 1995).

In addition to the framework of the UNESCO World Heritage Convention, the ICOMOS Charter and the European Cultural Convention both explicitly recognise the creation of 'archaeological reserves' as one of the measures that should be considered in heritage management (ICOMOS 1990; ECC 1992 in Appendix B). However, both the ICOMOS Charter and the European Cultural Convention do not give any guidelines as how one goes about creating 'archaeological reserves'. That is something left to the conservation workers because situation on the ground often requires different procedures, and may require distinct approaches.

Protected Locales

An option to actually establishing 'archaeological reserves' is to determine how many archaeological sites are currently located in National Parks, Nature Reserves, and other protected locales. As it has been pointed out before national legislation that applies to these areas mean that any archaeological site within these areas is protected to a degree in the sense that any development inside the protected areas is monitored

and controlled. Knowing how many archaeological sites are located within these protected locales, and their profile with regards to culture, type, remains found, et cetera will give archaeologists an idea of what is being conserved. Furthermore, armed with that knowledge archaeologists can inform the curators of these locales about the resource that is under their care and advise them on its potential and ways to conserve the resource.

Figure Map 3 (in Appendix C) shows some of the proclaimed protected locales in the study area and the distribution of archaeological sites. In total about 450 square kilometers - 2.9 percent - of the study area is currently under some form of protection. The legislation for the management of these locales falls under various Government Department, and some are under private hands. Hence there tends to be little or no meaningful corporation in their management. In addition, this protection does not necessarily extend to archaeological sites - the sites are protected by virtue of being inside a protected locale.

Only 53 out of 2144 known archaeological are located within the protected locales found in the study area – 2.47 percent. Table A.1 (Appendix A) is a summary table of the archaeological sites that are within the protected locales. Amongst the sites located in the protected there are conspicuous limitations. First and foremost the sample is very small - only 2.47 percent - compared to all the known sites in the study area. Secondly the sample is comprised solely of LSA sites. Last but not least there is a glaring lack of caves and rock art sites.

The purpose of this exercise is to determine if the profile of the archaeological sites inside protected areas is similar with that of all the archaeological sites. If that is so, there maybe a case can be made that the number of archaeological sites within these protected areas represent a sample that is deemed 'sufficient' and similar in profile to the total number of sites, therefore enough of the known cultural resources are under some form of protection. Without going into too much detail and without even determining what is 'sufficient', it is apparent that is not the case. Hence it can be

concluded that the archaeological sites within the protected locales are not sufficient enough for archaeologists to rely on. Nevertheless it worth to take note of these sites and even inform the relevant authorities on their presence so as to ensure their survival.

One of the reasons why there are only a pitiful number of archaeological resources located in the protected locales is the proportion of these areas that have been surveyed for archaeological resources. One of the most important source of information about archaeological resources in the study area is the Cultural Resource Management (CRM) work that has been done up to date. CRM in turn is a by-product of industrial and residential development, mining activity, and agricultural development that are taking place in the study area. Protected locales - National Parks and Nature Reserves - because of the limited or absent development taking place within their boundaries, so little archaeological work has been done. As a results the number of archaeological sites located in the areas is small. One way to deal with this apparent lack of information is to use the results of the Archaeological Sensitivity Model in order to identify protected locales with high archaeological sensitivity. In that way we will not only know which protected locales have archaeological sites, but also know which ones are most likely to have sites. That information can then be factored in any management decisions made about cultural resources.

The various protected locales - National Parks, Nature Reserves, RAMSAR sites, and other protected areas - where evaluated in order to determine which of them had 'low', 'medium', and 'high' archaeological sensitive within their boundaries, and the results are given in Table 9.1. According to Table 9.1, the Orange River Mouth, Verlorenvlei, Elandsbaai and SAS Saldanha have more than 50 percent of their total area flagged as 'high' potential areas for the presence of archaeological resources. Langebaan Lagoon, Blouberg, Columbine, West Coast National Park, Lutzville, and Rocherpan have more than 10 percent of their total flagged as 'high' potential areas. Now the responsibility is on cultural resources managers to let the relevant agencies/authorities responsible for the management of the protected locales to know about the archaeological potential of the area in their care. This type of exercise can

even be extended for mining concessions in the study area, agriculture, forestry, residential and industrial developments.

Name	%Part Low	%Part Medium	%Part High
ORANGE RIVER MOUTH	0	5.4	69.17
VERLORENVLEI	0.04	48.37	51.58
MARCUS ISLAND	100	0	0
MALGAS ISLAND	0	0	0
JUTTEN ISLAND	0	0	0
LANGEBAAN	2.3	11.52	17.2
West Coast National Park	25.14	64.38	10.46
PLATTEKLOOF 430	85.9	14.09	0
9 Divisie HK (Ou 6BKD)	95.12	4.8	0
ALTYDGEDACHT	100	0	0
Columbine	15.14	45.92	38.93
Durbanville	100	0	0
Tygerberg(Parrow)	86.37	13.62	0
Tygerberg(Bellville)	71.33	28.67	0
Lutzville	16.13	72.09	11.77
Elandsbaai	0	45.69	54.3
Rocherpan	3.1	73.55	23.3
Paternoster Rock	100	0	0
SAS Saldanha	5.1	26.9	67.9
Blouberg	1.7	62.87	35.42

Table 9.1 Protected Locales with Relative Levels of Archaeological Sensitivity.

‘Archaeological Reserves’ I

The vehicle for determining these ‘archaeological reserves’ will be two sets of regular grids superimposed over the study area. One grid will be 10x10-kilometre in size, and

the other will be 5x5-kilometre. The reason for using different grid sizes is to see if they give different results. In order to determine areas that can be regarded as 'archaeological reserves' we will try to use biological concepts like density, diversity and rarity. These concepts were introduced in an earlier section - Chapter 6. The density, rarity and diversity index will be calculated for each square, and the results will be displayed as a map. The idea is to determine if there are regions in the study area with high values for all the indices that can form a continuous 'patch' of land that can be possibly proclaimed as a 'archaeological reserves'. The objective here is not to really carry out the process of proclaiming a 'archaeological reserves', but to show how one would go about it if they were given the task offer alternative scenarios.

The density indices for the distribution of archaeological sites in the study area for the 10x10-kilometre grid are given in Table A.2 (Appendix A). The mean density of archaeological distribution in the 10x10 grid is 1.33 sites per square kilometre with a standard deviation of 2.23. The maximum density is 11.76 and the minimum is 0.01 sites per square kilometre. The number of grid squares that have density values ≥ 1 Standard Deviation above the mean is 17 and they are listed in Table A.3 (Appendix A). The total area covered by these squares is 351.8 square kilometers - 2.3 percent of the study area. The number of archaeological sites located within these grid squares is 787 - 36.7 percent of all known sites.

The variation in diversity indices for the 10x10-kilometre grid sites with regard site types in the study area is given in Table A.4 (Appendix A). The indices calculated for each square are H - index of general diversity, e - index of evenness, d - index of diversity, c - index of dominance. Using the general diversity index - H , the mean for the 10x10-kilometre grid is 0.55 with a maximum of 1.7 and a minimum of 0. The standard deviation is 0.5 and there are 38 grid squares with a diversity index greater or equal to the mean (Table A.5, in Appendix A). The grid squares with a diversity index greater than the mean cover have 1880 archaeological sites within - 87.68 percent - and they cover 2041 square kilometers - 13.3 percent of the study area.

An additional variable that is often used by natural scientists in order to determine nature reserves is the presence of rare and endangered species. In archaeological terms this is analogous to giving special attention to 'charismatic' or spectacular archaeological sites - not an entirely objective decision. For example, with 97.8 percent of known archaeological sites being Later Stone Age, that means any older sites should be regarded as 'charismatic'. This is not the same as saying that Later Stone Age sites are not important or have no value, but based on the resource that we know the other sites are 'rare' and deserve extra attention. One way to give special attention to these 'rare' sites is to highlight the grid squares that have MSA and ESA sites for a potential 'archaeological reserves'. A more systematic way to go about the objective is to calculate diversity indices for the grid squares using cultural affiliation instead of typology. In that way the so-called 'charismatic' sites are included in the 'culture reserve' as part of a 'system'. The results of the exercise are outlined below.

The same diversity indices were calculated for the 10x10-kilometre grid using the cultural affiliation of archaeological sites instead of typology. The diversity indices are given in Table A.6 (Appendix A). Using the cultural affiliations of the sites, the mean general diversity index for 10x10 grid is 0.104113 with a standard deviation of 0.212117. There are 16 squares that are ≥ 1 Standard Deviation above the mean and they are listed in Table A.7 (Appendix A). These squares have 478 archaeological sites - 22.2 - located inside and they cover 1127 square kilometers of the study area - 7.3 percent.

There are various ways to delineate the boundaries of our 'archaeological reserves'. One is to find the grid squares that are common to all measurements - density, typological diversity, and cultural diversity - then combine these to form the reserve. Another way is by picking the grid squares that have excelled in at least two of the measurements. The third way is to combine the square grids that have excelled in all three measurements.

The purpose of this exercise is to find an area or regions that will conserve whole cultural systems and the biological or environmental processes that maintain these systems. For that goal to be fulfilled we have to try to find a way of determining the

'culture reserve' that is holistic. As a result, in order to delineate the boundaries of the proposed 'culture reserve' for the 10x10-kilometre grid, the squares that are exceptional in all measurements - density, typological diversity, and cultural diversity - will be combined in order to form the boundaries of the 'culture reserve'. The squares that are combined to form the 'culture reserve' are in Table A.3, A.5, and A.7 (Appendix A) for the 10x10-kilometre grid. Map 16 (in Appendix C) is the resultant 'archaeological reserves' when using the 10x10-kilometre grid and covers 2749 km² - 17.8 percent of the study area. There are 2000 archaeological sites located within this reserve - 93 percent of all known sites.

As a heuristic device the same procedure was conducted for the 5x5-kilometre grid to calculate a density index. The results for the density of archaeological sites in 5x5-kilometres grid are tabulated in Table A.8 (Appendix A). For the 5x5-kilometre grid the mean density of archaeological distribution is 2.033427 sites per square kilometre, with a maximum of 70.76, a minimum of 0.04, and a standard deviation of 6.45. There are 32 grid squares with a density values ≥ 1 standard deviation above the mean and they are listed in Table A.9 (Appendix A). These grid squares cover 341.4 square kilometers - 2.21 percent of the study area - and there are 1179 archaeological sites located in them - 54.9 percent of all known sites.

The diversity indices for the 5x5-kilometre grid are listed in Table A.10 (Appendix A). The mean for the general diversity index is 0.47417 with a standard deviation of 0.479856. There are 63 grid squares (Table A.11 in Appendix A) with a diversity value greater or equal to the mean index and they cover 1148 square kilometre of the study area - 7.46 percent. There are 1571 archaeological sites located inside these squares - 73.7 percent of all known sites.

The diversity indices for the 5x5-kilometre grid using the cultural affiliation of an archaeological site are given in Table A.12 (Appendix A). The mean for the general diversity index is 0.059298 with a standard deviation of 0.0159528. There are 23 5x5-kilometre grid squares with a diversity value ≥ 1 Standard Deviation (Table A.13 in Appendix A).

In order to delineate the boundaries for the boundaries for the 5x5-kilometres grid the exceptional grid squares in Table A.9, A.11, and A.13 are combined. The 5x5-kilometre grid 'culture reserve' covers 1278 km² - 8.3 percent of the study area. There are 1756 archaeological sites located inside the reserve - 81.9 percent of all archaeological sites (see Map 17 in Appendix C).

'Archaeological Reserves' II

Using the known archaeological sites to develop 'archaeological reserves' allows us the opportunity to use concepts such as diversity in Cultural Resource Management, but has one major limitation. Whatever the results of the exercise we get, its value is suspect because it only deals with the known archaeological sites without offering any suggestion on how to deal with the unknown. That becomes an even more glaring limitation when you consider that only 10 percent of the study area has been surveyed for archaeological resources. Having just developed an Archaeological Sensitivity Model it would seem to be the perfect opportunity to use it to identify areas that can be possible 'archaeological reserves'. This is done on the assumption that the results of the Archaeological Sensitivity Model are reasonably accurate.

Again the two grid squares - 10x10 and 5x5-kilometres - will be used as a heuristic device to showcase different possibilities of solving the issue. The results of the Archaeological Sensitivity Model will be used to identify grid squares that have a significant portion of their area flagged 'high' sensitivity zones. Anything > 1 Standard Deviation from the mean - 41.4 percent and 45.685 percent flagged as 'high' for the 10x10 and 5x5-kilometres grids respectively- was regarded as significant. The outcome will be two 'archaeological reserves' for the two grid sizes based on the predicted location of archaeological sites in the study area.

For the 10x10-kilometres grid squares there are 58 squares with more than or equal to 41.4 percent of their area flagged 'high' according to the Archaeological Sensitivity Model (see Table A.14 in Appendix A). The resulting 'Culture Reserve' for the

10x10-kilometres grid is Map 18 (in Appendix C). The reserve covers an area of 2699 square kilometers.

For the 5x5-kilometres grid there are 168 squares with more than or equal to 45.685 percent of their area flagged 'high' according to the Archaeological Sensitivity Model. (see Table A.15 in Appendix A). The map for the 5x5-kilometres grid is given in Map 19 (in Appendix C). The 5x5-kilometres reserve covers an area of 2739 square kilometers.

What is obviously apparent is the difference between the two sets of 'archaeological reserves' - between the ones developed using the locations of known archaeological sites, and the second set developed using the Archaeological Sensitivity Model. It would seem therefore that there is no uniform and consistent way to go about identifying areas for the establishment of a 'Culture Reserve'. Nevertheless, what we have here are some of the ways to go about the process.

An additional piece of information is that now archaeologists can attempt to play an active role in forums that are debating the establishment of National Parks, Nature Reserves, and other conservation areas. For example in the debate about the establishment of National Park between the Spoeg River and the Groen River, archaeologists can participate by consulting some of the maps produced by this exercise (see Map 18 & 19 in Appendix C). Archaeologists can fully endorse the establishment of the National Park on the grounds that based on our Archaeological Sensitivity Map any conservation measures that are applied in the said area are likely to benefit cultural resources. In future, archaeologist can even enter the planning framework at an even earlier stage and even suggest areas to be declared conservation zones.

Discussion

The introduction of a 'archaeological reserves' concept in the management of archaeological resources will pose many problems for planners and heritage managers. Instead of managing individual archaeological sites, archaeologists have to conserve large areas of relict landscapes and continuing organic landscapes alike which will require new attitudes to conservation and management. As a result new approaches and strategies will have to be adopted, which will ensure the preservation of the traces of the past in the landscape without impeding or arresting the social and economic development of those who live it.

What are the realistic chances of actually establishing a purely 'culture reserve'? Consider the fact that when a society decides to establish a reserve, it wants to fund the conservation of resources that make a substantial and varied contribution relative to the costs involved. This means in addition to the information about the diversity indices, society needs the requisite data on the costs of reducing the destruction of the resource. For this alternative management plan to be effective it must realise cultural resource benefits, sustain cultural resource benefits, and promote proactive and co-operative governance.

For environmental resources managers this is nothing new. For example natural resource managers have a working estimate of all coastal benefits. In South Africa the current value of coastal goods and services annually is R179 billion which constitute 37 % of Gross Domestic Product (GDP) (DEA&T 1998). In addition to the valuation of goods and services the coast has aesthetic, cultural, educational, scientific, and spiritual values. This valuation is conservation, illustrative and highlights the importance of coastal, but more importantly it gives resource managers something to start with when faced with management decisions. In order to sustain the benefits natural resource managers attempt to manage the coast in a way that recognises its inter-connected nature, or they will lose the social and economic benefits. This proactive way of looking at resource management strengthens institutional

arrangements, promotes co-ordination and integration of planning, and strengthens the human resource base for coastal management.

For Cultural Resource Managers to determine the relevant costs they will need to know the relationships of archaeological sites to each other, relevant survival probability distribution, and the costs of improving site survival. With this knowledge will come the ability to calculate 'Conservation potential' of each grid square. Despite the obvious flaws and the generalisations inherent in this kind of exercise, there is something positive to be gained. Calculating the diversity and density indices for the grid squares in the study area has provided an operational analytical framework that given the right information can help guide actual conservation policy in a diversity-improving direction. Archaeologists do not always have that information available, and there is no framework in place to generate it. In addition, economic issues like Cost-and-Benefit analysis have not been fully investigated in cultural resource management and are not likely to find a popular audience among archaeologists who tend to regard the resource, hence the benefit, as being priceless but the costs as having a price.

The sooner archaeologists get to engage planners and developers in their language, the better. The end results will be a management plan that emphasises facilitation rather than regulation, suggests mechanisms for co-ordination of integration between different sectors. That is possible because by maintaining diversity and well being of cultural resources in the coastal zone we will realise and sustain the benefits and opportunities they provide.

The development of nature conservation and specifically the management of protected areas has moved away from the traditional concept that all protected areas were to be preserves solely as sacrosanct sanctuaries. The accommodation of lifestyles, aspirations and needs of local communities as part of the overall conservation ethic has become a globally accepted principle. The protected area system in South Africa presently consists of a variety of types of protected areas, managed for a variety of

purposes. What Cultural Resources managers need is to provide for the classification of protected areas on the basis of management requirements. For example nature conservation, in keeping with global trends, has a system that classify different categories for the conservation of wildlife sanctuaries. There are Scientific Reserves and Wilderness Areas, National Parks and Equivalent Reserves, Natural Monuments, Habitat and Wildlife Management Areas, Protected Land/Seascapes, and Sustainable Use Areas (Wahl & Naude' 1996). All these categories have different definitions, objectives, and criteria for selection and management. Below is a possible scheme of possible categories for cultural resources, which is in keeping with global trends in coastal zone management. The intensity of human use in protected areas shall vary according to the appropriate level of protection required to meet archaeological objectives, local needs and compatibility with activities.

The scheme suggested below is similar to the world-wide concept of biosphere reserves. In simple terms, biosphere reserves are a way of integrating nature conservation while at the same time maintaining the economic well being of the inhabitants of any particular region. The concept is achieved by dividing the region into zones, ranging from core areas where there has to be little or no human impact, through buffer areas where impacts are minimal, to transitional zones, where people live and work. The goal of these biosphere reserves is to realise sustainable development and conservation, integrated with the management of human needs and perception. Internationally more than 350 biosphere reserves have been registered by UNESCO (United Nations Educational, Scientific and Cultural Organisation).

Scientific Reserves

What is being envisaged are areas that possess some outstanding or representative cultural systems of scientific importance, which are available primarily for scientific research. The objective will be to maintain essential cultural processes, to preserve special cultural resources in an undisturbed state in order to have representative

examples for scientific study, and education. Any research activities will be planned and undertaken carefully to minimise disturbance, and public access will be limited to accredited research scientists, unless it is strictly supervised. These areas will be managed by a nationally recognised authority. The minimum size of the area should ensure the integrity and should accomplish the protection of the feature involved. The criteria for the selection of these reserves will be their scientific importance, and the only objective is the permanent preservation of the feature involved, with no development allowed which will have a direct bearing on this feature. Present features or area which could possibly be classified as Scientific Reserves are Elandsbay Cave, various megamiddens found along the coast, Diepkloof Cave, Steenbokfontein.

Areas of Cultural Significance

These refer to cultural features or areas of outstanding, unique scenic, educational or inspirational value. These areas or cultural features, because of their special interest, opportunities for interpretation, education, research and public appreciation, are protected. They often contain one or more features of outstanding significance which, because of uniqueness, rarity, should be protected. Areas or sites in this category may be state-owned and managed by either central or other government agencies, or owned and managed by corporations or private landowners as long as there is assurance that they will be managed to protect their special features for the long term. Present features or which could possibly be classified as Areas of Cultural Significance include most of the rock art sites found in the study area.

Sustainable Use Areas

These are predominantly natural areas of land, designated and managed to ensure the long-term protection and maintenance of its cultural diversity, whilst bringing benefits that contribute to the welfare and development of the local community. The

designated areas should be large enough to absorb sustainable resource uses without detriment to its long-term cultural value. Management of these areas should be undertaken in partnership with the local community or through local councils. Present features or areas which, could possibly be classified as Sustainable Use Areas include Verlorenvlei catchment area, Vredenburg Peninsula.

Summary

In this chapter we introduced the notion of a 'patch' strategy in the conservation of archaeological resources. This notion is based on proven methods in environmental management - the question is does it work for cultural resources? The answer is possibly yes provided we are talking only about known archaeological sites, and we need to bear in mind that only about 10 percent of the study area has been surveyed for archaeological resources. What about the 90 percent that has not been surveyed?

Having developed an Archaeological Sensitivity Model for the study area, the unsurveyed 90 percent has not been neglected. Archaeologists and developers are now in a position to use this information to the better conservation of cultural resources. For the first time there is a framework to warn developers about the likelihood of archaeological resources being found, hence they can be better prepared and make prior arrangements so as to avoid delays and possibilities of breaking the law. Furthermore the Archaeological Sensitivity Model can be integrated with other environmental management plans in the establishment of conservation areas.

Conservation has in the past often been thought of as protective locking away of resources by a powerful elite, a concept which persists today. This led to the belief that these areas were only for the benefit of the powerful and rich. The World Conservation (IUCN 1980) demonstrates how the conservation of resources is essential for the sustaining development by :

- Maintaining the essential ecological processes and life support systems;
- Preserving genetic diversity;

- Ensuring that utilisation of species and ecosystems is sustainable.

These objectives should not in any way differ from what archaeologists should strive for in the conservation of archaeological resources, except for minor changes in the wording. It is now recognised that, when designed and managed appropriately, protected areas offer major sustainable benefits to society. They can play a centre role in the social and economic development of rural environments and contribute to their economic well-being. In view of the rapid development and population increase, coupled with the great speed with which cultural resources are being depleted, there is considerable urgency in establishing protected areas if we are to achieve the objectives of the World Conservation Strategy.

The establishment of protected areas in Cultural Resource Management will play a dynamic role in facilitating the positive awareness and exchange of information amongst all interested groups. This will further ensure the co-operative, and sustainable management of South Africa's cultural resources. The dynamism will be enhanced by cultural resources managers continually reviewing the protected areas, and clarifying the justification and objectives for each reserve. This will further increase the management efficiency in each area, and afford the ability to accommodate other forms of utilisation if these are compatible with the protection requirements.

CHAPTER 10. INTEGRATED MANAGEMENT

According to Deacon (1996) the institutional framework of any management plan has to take into account three broad factors, legislation, infrastructure and information or inventories. The latter, information, is the main objective of this project. The challenge facing heritage management is to have inventories that are accessible enough to provide maps of site locations, allow the relative significance of sites to be assessed, have a facility to analyse information so that predictive models can be generated for areas that have not been surveyed, and be maintained with minimum cost in effort and finance (Deacon 1996). Inventories are the primary information resource for heritage management and planning, and they help avoid crisis management by providing an early warning system for planners, archaeologists and developers. Now it is time to take stock of what has been achieved in this project.

Overview of Archaeological Data

This project takes on where Kaplan's (1993 & 1995) projects ended and attempt to address any shortcomings and recommendations that were suggested. First it was recommended that the management of cultural resources should be fully integrated in the earliest stages of environmental assessment, so as to increase the awareness among local authorities of the significance of cultural resources. Secondly, it was recommended that the archaeological database be upgraded and maintained on a regular basis. The third recommendation was that the archaeological information was incorporated with Geographical Information Systems and updated to the level of 1 : 10 000 maps. The fourth recommendation was that the known archaeological site information is used to derive an archaeological predictive model in order to facilitate Cultural Resource Management and as a research tool. Last but not least it was recommended that the information be made available to provincial planning authorities and other interested parties. How far have we gone in addressing these recommendation?

All the existing information on archaeological resources in the Cape West Coast has been documented and entered as overlays in a GIS system. The rationale behind setting up the inventory is based on the premise that the information can be used to predict where archaeological sites may occur in areas that have not been surveyed, assess the relative significance of sites and projects, and to plan for Cultural Resource Management. Once the data capture was complete, then the spatial distribution of archaeological sites was manipulated statistically together with chosen environmental variables to develop an Archaeological Sensitivity Model.

The Archaeological Sensitivity Model is a map indicating areas of varying archaeological sensitivity, rather than exact point data, in areas that have not been surveyed for cultural resources. The main function of the Archaeological Sensitivity Model is to provide an early warning system for planners, archaeologists and developers about the possibilities of finding archaeological sites. With the development of the Archaeological Sensitivity Model there are limitless possibilities to Cultural Resource Management. It will no longer be a “dream” to consider this sequence of events:

“In optimistic mode, we may dream of a time when, with little more effort than a gentle click of a mouse, a full colour map will emerge from a dedicated printer highlighting with clarity and insight where sites are or may be located. The accompanying information will indicate the relative importance of each site at local, provincial and national level, what work has been done there in the past and what mitigation is recommended. As the developers take a copy of the map and beam with pride in the knowledge that their property is indeed of significance in the history of our country, a contract and a cheque are signed for the archaeologists to begin work immediately. The archaeologist gathers the waiting team and equipment together and drives off, secure in the knowledge that the information generated by the work about to be done will benefit not only the careers and bank balances of the team members, but the successful management of the archaeological resources as well. ... Our dreams may even conjure up a dozen other projects that could be generated from the information in our archaeological inventory, but which have never been contemplated before.” (Deacon 1996).

With the necessary infrastructure in place the Archaeological Sensitivity Model means that this is not just a “dream”, but something that is possible. With the Archaeological Sensitivity Model archaeologists are now in a position to integrate their knowledge on cultural resources to planning authorities and ensure that archaeological heritage forms part of the planning process at the earliest stages.

A corollary function of the Archaeological Sensitivity Model is the ability to use it to identify new research projects. For example we can use the Archaeological Sensitivity Model to identify the sites that are located in areas which according to the model are least likely to have cultural resources. Then we can look for similar areas in terms of environmental characteristics, and if we happen to find more archaeological sites that information can be fed back to improve the model.

Management Plan

A recent United Nations report (GESAMP 1996) defines coastal management as:

“A continuous and dynamic process that unites Government and the community, science and management, sectoral and public interest in preparing and implementing an integrated plan for the protection and development of coastal ecosystems and resources.”

The Coastal Management Policy Programme is the initiative of the Department of Environmental Affairs and Tourism whose goals are to promote meaningful public participation, develop policy that has scientific integrity, promote integrated coastal management, and develop a practical policy. The integration of Cultural Resource Management in Coastal Management Policy Programme will lead to a new era of coastal management in South Africa.

Cultural Resource Management is a process that requires creative partnerships to be established between Government, academic institutions, civil society and the private sector. To manage cultural resources for the benefit of current and future generations, such partnerships will need to be based on the integration of a range of considerations, including policy, management, education and applied research. Developing an

integrated cultural resource management approach is not an easy task, and needs to be worked toward, progressively, over time. Such an approach is particularly difficult to initiate in the context of strongly entrenched sectoral management practices. Nonetheless, if we are to sustain the benefits provided by cultural resources, there is a need to work towards integrated management. First, attention needs to be drawn to the subject of cultural resource management. Then, awareness needs to be built around the subject. Dialogue needs to be fostered amongst the various role-players. Co-operation can then be promoted, followed by co-ordination of activities. Finally, integration can then be realised.

Since the 1970s there has been a number of important innovations in coastal management (DEA&T 1998). First the world-wide trend in coastal resource management is a shift from a resource-centred approach towards a people-centred approach. Instead of being exclusively concerned with technical issues, coastal resource managers are increasingly concerned with governance issues. Secondly the role of science is changing from being the driver of the policy process towards being the principal vehicle for informing the process. Science is increasingly being used to inform policy debates and clarifying options for and implications of different policies. Thirdly there has been a shift from a "restoration and mitigation" approach to an "anticipatory and precautionary" approach. This change is prompted by the experience of cumulative impacts of individually insignificant actions, the high cost and frequent failure of restoration effort in coastal resources management. Last but not least there has been an expansion of the tools used to achieve coastal management objectives. Greater emphasis on proactive and co-operative approaches, with regulation and enforcement used as a last resort.

For Cultural Resource Management to be at the forefront of conservation exercises archaeologists have to take these innovations into account. This is the case because natural resources are not only the 'scenery' against which the cultural drama took place. Natural resources are responsible for setting limits to human population growth and as to how populations arrange themselves upon the landscape. It is necessary to understand the procedures involved in natural resource management in order to ensure

that any interpretation of the results of archaeological resource management are based on a clear understanding of the regulating factors imposed by the environment. Furthermore, according to Agenda 17 of Chapter 17 of the United Nations Conference on Environment and Development simplicity and integration of the physical world are two important institutional aspects of a management plan. Integration of Cultural Resource Management in other conservation exercises is a must if any meaningful results are to be attained.

Geographic Integration

For the integration of Cultural Resource Management in Coastal Management Policy Programme to work it has to take place at different levels and spheres. There is a need for geographic integration, because cultural resources are inter-connected and no single organisation can have overall control. Attention must therefore be given to the inter-connections between the land and sea environments, which can extend over vast distances.

To some extent geographic integration has been achieved in this project. Cultural resources used in this project are located along the coast, in the coastal plain, and in the hinterland. Hence there is inter-connection between the coast and the hinterland. With little effort there is scope for even more, inter-connecting the land and sea environments. For example that can be achieved by the addition of information about shipwrecks in the database.

Integration across time scales

Integration across time scales - short-, medium-, and long-term implication - in order to attend the consequences of cumulative impact of many individual decisions made and actions taken by resource users. For example when making decisions about

development we need to consider the impacts of the particular project during site preparation, infrastructure, operation, and decommissioning and closure (Fuggle & Wiseman 1994). A practical example will be the consideration of the implications for the establishment of the Saldanha Steel Project on cultural resources located in the immediate area. Cultural resources managers need to clearly outline the implication not only of the Saldanha Steel Project itself in the immediate future, but the long term effects of the project itself and any secondary developments that takes place subsequently.

This project, by the virtue of not looking at archaeological sites in isolation achieves integration across time scales. For example the Archaeological Sensitivity Model allows us the ability to model what happens to the resources on a regional scale when a development takes place. We can determine the number of archaeological sites that will be impacted by the development and factor that information into the database. The result will be a new picture of the regional distribution of archaeological resources. Furthermore we can factor in secondary developments that take place subsequently even before they happen.

Integration across sectors

Often referred to as “horizontal integration” and includes diverse sectors such as agriculture, commerce, forestry, industry, mining, reserves, recreational and residential developments, tourism and transport infrastructure. Attention must be given to “horizontal integration” of sectors traditionally seen to be separate, together with the associated governmental agencies that influence planning and management of cultural resources.

Archaeologists should be actively seeking to play a role in the conservation strategies of environmental resources. For example, by actively participating in forums dealing

with the establishment of the National Park between the Groen River and the Spoeg River. By letting various conservation agencies know about the Archaeological Sensitivity Model. The Archaeological Sensitivity Model can be integrated our knowledge of where the National Parks, Nature Reserves, and other protected locales are in the study area. By doing so archaeologists will educate the custodians of these locales about the potential for the presence of cultural resources, and thus they will reconsider their management approaches to acknowledge the sensitivity regarding archaeological resources.

For the first time archaeologists can actively and positively participate in debates concerning conservation plans with a reasonable amount of conviction about their knowledge. For example archaeologists are now in a position to endorse or not to endorse the proclamation of a National Park between the Groen River and the Spoeg River based on the results of the Archaeological Sensitivity Model.

Political and institutional integration

Political and institutional integration is sometimes referred to as “vertical integration”. “Vertical integration” is necessary in order to attend the challenge posed by the fact that boundaries of cultural resources go beyond local, provincial and often national areas of authority. There is therefore a need for “vertical integration” between spheres of Government from the local to the international level, and institutional integration between Government, society and the private sector.

Present day political boundaries were not in place during prehistoric times, hence they do not correspond to archaeological resources. For example the study area for this project encompasses two political provinces, the Western Cape Province and the Northern Cape Province. There is scope to take “vertical integration” for this project

even further. There might come a time when the Archaeological Sensitivity Model will cross an international boundary and include parts of Namibia.

Integration across disciplines

Cultural resources are multi-faceted, dynamic and complex. Attention must therefore be given to integrating knowledge and understanding from the natural and social sciences, the humanities and the design professions (including engineering, planning and architecture). In addition, archaeological research must be integrated with other sources of information, including the knowledge of coastal communities and users.

Attempts at establishing 'archaeological reserves' are tapping on the knowledge from natural scientists. There are other possibilities for improving the Archaeological Sensitivity Model even further by working closely with geographers, computer scientist, anthropologists, architects and other design professionals.

Policy, management, education and research

Cultural resource management is a process that requires creative partnerships to be established between government, society and the private sector. For the effective management of cultural resources in order for the future generation to benefit, the partnerships between government, public sector and the private sector will need to be based on the integration of a range of considerations, including management, policy, education and research.

Discussion

There are a number of important questions that need to be considered before any new conservation approach is considered. First archaeologists need to be concerned about

the scope of their policy decisions. A large number of projects and ideas have failed in the past because the people involved have tried to do too much and in the process have spread themselves too thinly. Ideally the scope of policy must increase through the successive completion of goals and objectives, instead of trying to achieve everything at the same time. For example it does not make sense to try to develop an Archaeological Sensitive Model for the whole country at the same time, a more measured approach will be to develop regional models and then combine all of them to form a model for the whole country.

Secondly, archaeologists need to decide the appropriate approach to policy development. In the past most conservation measures tended to take a more prescriptive approach rather than a facilitative one to resource management, and had minimal or no public participation in policy formulation and implementation. For Cultural Resource Management to work effectively the approach to policy development has to change. Any policy developments have to emphasise economic and social benefits that can be derived, should have meaningful public participation in policy implementation and formulation and should involve some form of capacity building for the local communities in the form of training, budgetary allocation, assistance for managing consultants.

Thirdly, clear and precise institutional arrangements have to be in place for any new developments to work. There has to be a clear separation of national, provincial and local responsibilities in Cultural Resource Management. Crucially the way forward is the designation of a lead agency for the conservation of archaeological resources. Currently that function is being performed by the National Monuments Council. As part of a new legislative framework the National Monuments Council will be replaced by the South African Heritage Agency (SAHA), with clearly set out rules and jurisdiction for both the National and Provincial governments. The cornerstone of the new legislative framework is integrated planning at local level and mandatory impact assessments for any new developments. In addition to the designation of a lead agency there is a need for the establishment of strategic alliances with other government departments that have a stake in cultural resources. For example, the Department of

Water Affairs, Department of Environmental Affairs and Tourism, Department of Minerals and Energy, and the Department of Agriculture.

Fourthly, the designated lead agency has to modify and supplement the instruments it uses for the implementation of conservation strategies. Legislation and regulation will still remain the cornerstone of any conservation exercises but there is room for change. For legislation to be effective there must be appropriate and sufficient information upon which to base legislation. The process of legislation must lead to clear and understandable laws. Last but not least, the laws must be robust and enforceable (Odendaal 1994). Additional instruments include education and training in order to increase awareness and build capacity for the implementation of conservation strategies, direct development of public access points to sensitive areas, and economic instruments in the form of investment incentives, taxes and fines. The use of economic instruments in Cultural Resource Management is a new and unexplored entity. There are generally four main types of economic instruments, taxes and charges, market creation, deposit return and subsidies (DEA&T 1993), but only the first and the last one are really applicable to cultural resources. The taxes and charges will be prices that developers will have to pay for the destruction of cultural resources. Both the taxes and charges have a revenue raising and incentive effects.

Last but not least archaeologists need to conduct research, monitoring and review of the conservation approach they are employing. This is necessary in order to identify problems and solutions, provide positive feedback, and track the impact of the programme to ensure continual improvement and promote accountability.

APPENDIX A

Name	Culture	Type	Art	Shell	Stone	Oes	Fauna	Pottery
CCL 1	LSA	Open site	0	1	1	0	1	1
TTB 1	LSA	Deflation	0	1	0	0	0	1
TTB 2	LSA	Deflation	0	1	1	1	0	1
TTB 3	LSA	Deflation	0	1	1	1	0	0
DM 2	LSA	Open site	0	1	0	0	0	0
LL 1	LSA	Midden	0	1	1	1	1	0
LL 2	LSA	Midden	0	1	0	0	0	0
LL 3	LSA	Midden	0	1	0	0	1	0
LL 4	LSA	Open site	0	1	1	0	1	1
LL 5	LSA	Open site	0	1	1	1	0	1
LL 6	LSA	Midden	0	1	1	0	0	1
LL 7	LSA	Midden	0	1	1	0	0	0
LL 8	LSA	Midden	0	1	0	0	1	0
LL 9	LSA	Midden	0	1	1	0	0	0
LL 10	LSA	Rock shelter	0	1	1	0	0	0
LL 11	LSA	Midden	0	1	1	0	0	0
LL12	LSA	Midden	0	1	0	0	0	0
LL13	LSA	Midden	0	1	1	0	0	0
LL14	LSA	Stonewall	0	0	0	0	0	0
LL15	LSA	Midden	0	0	1	1	0	1
LL16	LSA	Open site	0	0	0	0	1	0
JUT 1	LSA	Deflation	0	1	0	0	0	0
JUT 3	LSA	Rock shelter	0	1	1	0	0	0
JUT 4	LSA	Midden	0	1	1	0	0	0
JUT 5	LSA	Open site	0	1	0	0	0	0
JUT 6	LSA	Midden	0	1	0	0	0	0
SH 1	LSA	Open site	0	1	1	0	0	0
KE 1	LSA	Open site	0	1	1	1	1	1
GB 1	LSA	Deflation	0	1	1	1	0	1
CC 14	LSA	Midden	0	1	1	0	0	0
Bekbaai 1	LSA	Midden	0	1	1	1	0	1
KTB	LSA	Open site	0	1	1	1	1	1
V 1	LSA	Open site	0	1	1	1	1	1
V 2	LSA	Open site	0	1	1	1	1	1
V 3	LSA	Open site	0	1	1	1	1	1
DS	LSA	Open site	0	1	1	1	1	1
DSM	LSA	Open site	0	1	1	1	1	1
GYP 3	LSA	Open site	0	1	0	0	0	0
GYP 4	LSA	Open site	0	1	0	0	0	0
GYP 5	LSA	Open site	0	1	0	0	0	0
GYP 6	LSA	Open site	0	1	0	0	0	0
GYP 7	LSA	Open site	0	1	0	0	0	0
GYP 8	LSA	Open site	0	1	0	0	0	0
GYP 9	LSA	Open site	0	1	0	0	0	0
GYP 10	LSA	Open site	0	1	0	0	0	0
GYP 11	LSA	Open site	0	1	0	0	0	0

GYP 12	LSA	Open site	0	1	0	0	0	0
GYP 13	LSA	Open site	0	1	0	0	0	0
GYP 14	LSA	Open site	0	1	0	0	0	0
GYP 15	LSA	Open site	0	1	0	0	0	0
GYP 16	LSA	Open site	0	1	0	0	0	0
GYP 17	LSA	Open site	0	1	0	0	0	0
GYP 18	LSA	Open site	0	1	0	0	0	0

Table A.1 Archaeological Sites within Protected Locales.

Grid10_id	Area	Number of Sites	Density
331	91.645	2	0.02182334
724	65.937	69	1.046453433
789	14.915	65	4.35802883
790	99.472	106	1.065626508
855	80.883	122	1.50835157
920	51.794	39	0.752982971
985	19.921	44	2.208724462
986	100.063	17	0.169892967
1050	4.101	29	7.071445989
1051	96.837	84	0.867437033
1116	72.048	30	0.416389074
1181	31.694	43	1.35672367
1246	2.592	21	8.101851852
1247	94.692	59	0.623072699
1312	68.368	81	1.184764802
1377	30.57	45	1.472031403
1378	100.054	5	0.049973015
1442	1.879	1	0.532197978
1443	96.93	5	0.051583617
1508	52.929	21	0.396757921
1835	7.125	51	7.157894737
1836	96.707	28	0.289534367
1901	46.349	3	0.064726316
2098	71.894	12	0.166912399
2099	100.024	27	0.269935216
2163	11.114	61	5.488572971
2164	99.163	3	0.030253219
2229	50.098	3	0.05988263
2557	58.233	9	0.154551543
2687	17.051	8	0.469180693
2688	100.004	10	0.099996
2752	10.336	22	2.128482972
2753	100.006	23	0.229986201
2754	98.692	10	0.101325335
2817	0.981	5	5.096839959
2818	91.479	77	0.841723237
2819	100	110	1.1
2882	0.51	6	11.76470588
2883	84.397	84	0.995296041
2884	100.002	64	0.6399872
2948	89.748	54	0.601684717
2949	100	177	1.77
3014	100.001	22	0.2199978
3139	0.461	1	2.169197397
3204	74.654	66	0.884078549

3205	36.352	11	0.302596831
3206	53.57	9	0.16800448
3268	18.286	66	3.609318604
3269	99.305	72	0.725039021
3333	14.047	23	1.63736029
3334	100.023	9	0.089979305
3398	4.253	6	1.410768869
3399	46.06	8	0.173686496
3400	78.615	36	0.457927876
3464	21.181	11	0.519333365
3465	64.368	24	0.372856078
3530	23.29	1	0.042936883
3531	96.764	1	0.010334422
3596	68.343	24	0.351169835
3661	25.313	2	0.079010785
3662	92.486	2	0.021624895
3727	25.034	3	0.119837022
3728	99.924	6	0.060045635
3792	4.769	1	0.209687566
3793	85.696	5	0.05834578

Table A.2 Density of Archaeological Sites in 10x10-kilometre grid.

Density = Number of Sites/ Area

Mean = 1.33

Standard Deviation = 2.23

Maximum = 11.7

Minimum = 0.01

GRID10_ID	Number of Sites	Density	Area
789	65	4.358029	14.91500
855	122	1.508352	80.88298
985	44	2.208724	19.92100
1050	29	7.071446	4.10100
1181	43	1.356724	31.69399
1246	21	8.101852	2.59200
1377	45	1.472031	30.57001
1835	51	7.157895	7.12500
2163	61	5.488573	11.11400
2752	22	2.128483	10.33600
2817	5	5.096840	0.98100
2882	6	11.764710	0.51000
2949	177	1.770000	100.00000
3139	1	2.169197	0.46100
3268	66	3.609319	18.28600
3333	23	1.637360	14.04700
3398	6	1.410769	4.25300

Table A.3 Squares with density values \geq 1 Standard Deviation of the Mean.

Grid10_id	N*	S*	H	e	d	C
331	2	1	0	0	0	1
724	69	3	0.151289	0.137709	0.472355	0.943499
789	65	2	0.079487	0.114676	0.239556	0.969704
790	106	1	0	0	0	1
855	122	2	0.04754	0.068586	0.208159	0.983741
920	39	2	0.119247	0.172037	0.272958	0.950033
985	44	1	0	0	0	1
986	17	2	0.223718	0.322757	0.352956	0.892734
1050	29	1	0	0	0	1
1051	84	3	0.129019	0.117439	0.451384	0.953373
1116	30	1	0	0	0	1
1181	43	1	0	0	0	1
1246	21	1	0	0	0	1
1247	59	1	0	0	0	1
1312	81	1	0	0	0	1
1377	45	1	0	0	0	1
1378	5	2	0.673012	0.970951	0.621335	0.52
1442	1	1	0	0	0	1
1443	5	1	0	0	0	1
1508	21	1	0	0	0	1
1835	51	1	0	0	0	1
1836	28	1	0	0	0	1
1901	3	1	0	0	0	1
2098	12	1	0	0	0	1
2099	27	2	0.264052	0.380947	0.303413	0.862826
2163	61	2	0.242036	0.349184	0.243257	0.877452
2164	3	2	0.636514	0.918296	0.910239	0.555556
2229	3	1	0	0	0	1
2557	9	3	0.936888	0.852792	0.910239	0.432099
2687	8	1	0	0	0	1
2688	10	1	0	0	0	1
2752	22	1	0	0	0	1
2753	23	1	0	0	0	1
2754	10	2	0.325083	0.468996	0.434294	0.82
2817	5	1	0	0	0	1
2818	77	2	0	0	0.230213	1
2819	110	2	0.090876	0.131107	0.212744	0.964298
2882	6	3	0.867563	0.78969	1.116221	0.527778
2883	84	3	0.129019	0.117439	0.451384	0.953373
2884	64	1	0	0	0	1
2948	54	2	0.092216	0.13304	0.25069	0.963649
2949	177	1	0	0	0	1
3014	22	1	0	0	0	1
3139	1	1	0	0	0	1
3204	66	2	0.078516	0.113274	0.238683	0.970156

3205	11	1	0.304636	0	0	0.834711
3206	9	1	0	0	0	1
3268	66	1	0.078516	0	0	0.970386
3269	72	2	0.07319	0.066621	0.467654	0.972608
3333	23	1	0	0	0	1
3334	9	2	0.348832	0.503258	0.45512	0.802469
3398	6	1	0	0	0	1
3399	8	2	0.661563	0.954434	0.480898	0.53125
3400	36	2	0.214559	0.309543	0.279055	0.895062
3464	11	1	0	0	0	1
3465	24	1	0	0	0	1
3530	1	1	0	0	0	1
3531	1	1	0	0	0	1
3596	24	1	0	0	0	1
3662	2	1	0	0	0	1
3661	2	1	0	0	0	1
3727	3	1	0	0	0	1
3728	6	1	0	0	0	1
3792	1	1	0	0	0	1
3793	5	1	0	0	0	1

Table A.4 Diversity of Archaeological Sites in 10x10-kilometre grid.

N = number of archaeological sites

S = number of site types

H = index of general diversity = $-\sum(P_i \log_e P_i)$, where P_i is the proportion of the sample in the i th type

e = index of evenness = $H/\log_e S$

d = index of diversity = $(S-1)/\log_e N$

c = index of dominance = $\sum(n_i/N)^2 = \sum(P_i)^2$

Grid10_id	N*	S*	H	e	d	c
2883	84	3	0.129019	0.117439	0.451384	0.953373
724	69	3	0.151289	0.137709	0.472355	0.943499
920	39	2	0.119247	0.172037	0.272958	0.950033
986	17	2	0.223718	0.322757	0.352956	0.892734
1051	84	3	0.129019	0.117439	0.451384	0.953373
1378	5	2	0.673012	0.970951	0.621335	0.520000
2099	27	2	0.264052	0.380947	0.303413	0.862826
2163	61	2	0.242036	0.349184	0.243257	0.877452
2164	3	2	0.636514	0.918296	0.910239	0.555556
2557	9	3	0.936888	0.852792	0.910239	0.432099
2754	10	2	0.325083	0.468996	0.434294	0.820000
2882	6	3	0.867563	0.789690	1.116221	0.527778
3205	11	1	0.304636	0.000000	0.000000	0.834711
3334	9	2	0.348832	0.503258	0.455120	0.802469
3399	8	2	0.661563	0.954434	0.480898	0.531250
3400	36	2	0.214559	0.309543	0.279055	0.895062

Table A.5 Squares with diversity values ≥ 1 Standard Deviation of the Mean.

N = number of archaeological sites

S = number of site types

H = index of general diversity = $-\sum(P_i \log_e P_i)$, where P_i is the proportion of the sample in the i th type

e = index of evenness = $H/\log_e S$

d = index of diversity = $(S-1)/\log_e N$

c = index of dominance = $\sum(n_i/N)^2 = \sum(P_i)^2$

Grid10_id	N*	S*	H	e	d	c
33i	2	1	0	0	0	1
724	69	2	0.669328	0.965636	0.236177	0.523629
789	65	2	0.658545	0.95008	0.239556	0.534201
790	106	3	0.908899	0.827316	0.428868	0.46084
855	122	3	1.083407	0.98616	0.416318	0.343053
920	39	2	0.119247	0.172037	0.272958	0.950033
985	44	2	0.625491	0.902393	0.264257	0.566116
986	17	4	1.006215	0.72583	1.058868	0.467128
1050	29	5	0.971429	0.603583	1.187897	0.543401
1051	84	5	0.949659	0.590056	0.902768	0.493764
1116	30	1	0	0	0	1
1181	43	2	0.404118	0.583019	0.265873	0.75987
1246	21	3	0.668018	0.608056	0.656917	0.619048
1247	59	2	0.681467	0.983149	0.245246	0.511635
1312	81	3	0.586557	0.533907	0.45512	0.684804
1377	45	3	0.404432	0.36813	0.525395	0.798519
1378	5	2	0.500402	0.721928	0.621335	0.68
1442	1	1	0	0	0	1
1443	5	1	0	0	0	1
1508	21	4	1.142472	0.824119	0.985376	0.360544
1835	51	1	0	0	0	1
1836	28	1	0	0	0	1
1901	3	1	0	0	0	1
2098	12	1	0	0	0	1
2099	27	2	0.158411	0.228538	0.303413	0.928669
2163	61	3	0.324564	0.295431	0.486515	0.847353
2164	3	1	0	0	0	1
2229	3	1	0	0	0	1
2557	9	2	0.686962	0.991076	0.45512	0.506173
2687	8	2	0.37677	0.543564	0.480898	0.78125
2688	10	5	1.359237	0.844541	1.737178	0.32
2752	22	3	0.367649	0.334649	0.647031	0.830579
2753	23	5	1.38036	0.857666	1.275716	0.293006
2754	10	4	1.279854	0.92322	1.302883	0.3
2817	5	2	0.673012	0.970951	0.621335	0.52
2818	77	6	1.398604	0.780576	1.151064	0.3014
2819	110	5	1.548655	0.962234	0.850977	0.224959
2882	6	4	1.242453	0.896241	1.674332	0.333333
2883	84	6	1.773526	0.989824	1.12846	0.172902
2884	64	3	0.640042	0.582591	0.480898	0.656738
2948	54	4	1.194573	0.861702	0.752071	0.324417
2949	177	5	1.37475	0.85418	0.772775	0.26675
3014	22	3	1.04126	0.947795	0.647031	0.367769
3139	1	1	0	0	0	1
3204	66	3	0.932951	0.849209	0.477366	0.449036

3205	11	2	0.541557	0.781301	0.417032	0.561983
3206	9	1	0.195467	0	0	0.604938
3268	66	4	1.033692	0.745651	0.716049	0.397153
3269	72	6	0.790461	0.441165	1.169135	0.640432
3333	23	3	0.754785	0.687035	0.637858	0.58034
3334	9	1	0	0	0	1
3398	6	1	0	0	0	1
3399	8	1	0	0	0	1
3400	36	2	0.214559	0.309543	0.279055	0.895062
3464	11	4	1.240684	0.894965	1.251097	0.322314
3465	24	3	0.785546	0.715035	0.629316	0.477431
3530	1	1	0	0	0	1
3531	1	1	0	0	0	1
3596	24	1	0	0	0	1
3661	2	2	0.693147	1	1.442695	0.5
3662	2	1	0	0	0	1
3727	3	1	0	0	0	1
3728	6	2	0.450561	0.650022	0.558111	0.722222
3792	1	1	0	0	0	1
3793	5	1	0	0	0	1

Table A.6 Cultural Diversity of Archaeological sites in 10x10-kilometre grid.

N = number of archaeological sites

S = number of cultural types

H = index of general diversity = $-\sum(P_i \log_e P_i)$, where P_i is the proportion of the sample in the i th type

e = index of evenness = $H/\log_e S$

d = index of diversity = $(S-1)/\log_e N$

c = index of dominance = $\sum(n_i/N)^2 = \sum (P_i)^2$

Grid10_id	N*	S*	H	e	d	c
2883	84	6	1.773526	0.989824	1.128460	0.172902
724	69	2	0.669328	0.965636	0.236177	0.523629
789	65	2	0.658545	0.950080	0.239556	0.534201
790	106	3	0.908899	0.827316	0.428868	0.460840
855	122	3	1.083407	0.986160	0.416318	0.343053
985	44	2	0.625491	0.902393	0.264257	0.566116
986	17	4	1.006215	0.725830	1.058868	0.467128
1050	29	5	0.971429	0.603583	1.187897	0.543401
1051	84	5	0.949659	0.590056	0.902768	0.493764
1050	29	5	0.971429	0.603583	1.187897	0.543401
1246	21	3	0.668018	0.608056	0.656917	0.619048
1247	59	2	0.681467	0.983149	0.245246	0.511635
1312	81	3	0.586557	0.533907	0.455120	0.684804
1312	81	3	0.586557	0.533907	0.455120	0.684804
1508	21	4	1.142472	0.824119	0.985376	0.360544
2557	9	2	0.686962	0.991076	0.455120	0.506173
2688	10	5	1.359237	0.844541	1.737178	0.320000
2753	23	5	1.380360	0.857666	1.275716	0.293006
2754	10	4	1.279854	0.923220	1.302883	0.300000
2817	5	2	0.673012	0.970951	0.621335	0.520000
2818	77	6	1.398604	0.780576	1.151064	0.301400
2819	110	5	1.548655	0.962234	0.850977	0.224959
2884	64	3	0.640042	0.582591	0.480898	0.656738
2882	6	4	1.242453	0.896241	1.674332	0.333333
2948	54	4	1.194573	0.861702	0.752071	0.324417
2949	177	5	1.374750	0.854180	0.772775	0.266750
3014	22	3	1.041260	0.947795	0.647031	0.367769
3204	66	3	0.932951	0.849209	0.477366	0.449036
3269	72	6	0.790461	0.441165	1.169135	0.640432
3268	66	4	1.033692	0.745651	0.716049	0.397153
3268	66	4	1.033692	0.745651	0.716049	0.397153
3333	23	3	0.754785	0.687035	0.637858	0.580340
3333	23	3	0.754785	0.687035	0.637858	0.580340
3464	11	4	1.240684	0.894965	1.251097	0.322314
3465	24	3	0.785546	0.715035	0.629316	0.477431
3465	24	3	0.785546	0.715035	0.629316	0.477431
3465	24	3	0.785546	0.715035	0.629316	0.477431
3661	2	2	0.693147	1.000000	1.442695	0.500000

Table A.7 Squares with cultural diversity values ≥ 1 Standard Deviation of the Mean.

Grid5_id	Area	Number of Sites	Density
1311	23.476	2	0.085193389
3008	22.3922	69	3.081430141
3138	12.76	51	3.996865204
3268	2.1758	14	6.434414928
3269	24.6296	107	4.344366129
3399	19.1537	90	4.698831035
3529	11.5304	26	2.254908763
3530	25.0163	5	0.199869685
3659	6.7296	24	3.566333809
3660	25.017	8	0.319782548
3790	19.9579	7	0.350738304
3920	13.6218	8	0.587293897
3921	25.0162	6	0.239844581
4050	6.3132	36	5.702337959
4051	25.0158	11	0.439722096
4180	4.1056	29	7.063522993
4181	25.0123	66	2.638701759
4311	21.8063	18	0.825449526
4441	15.6147	30	1.921266499
4701	0.7348	6	8.165487207
4702	22.3542	37	1.655169946
4962	2.6025	21	8.069164265
4963	24.8237	27	1.087670251
5093	19.8507	32	1.612033833
5223	14.9114	52	3.487264777
5353	3.8301	19	4.960705987
5354	24.642	10	0.405811217
5484	20.1897	16	0.792483296
5614	10.417	29	2.783910915
5615	25.0137	5	0.19989046
5744	1.8897	1	0.529184527
5875	21.9838	5	0.227440206
6005	8.1388	17	2.088760014
6006	25.0131	2	0.079958102
6136	19.7748	2	0.101138823
7310	6.8206	28	4.105210685
7311	25.0096	9	0.359861813
7440	0.325	23	70.76923077
7441	21.6882	19	0.876052416
7571	7.6934	3	0.389944628
8358	25.0065	2	0.079979205
8486	21.4865	12	0.558490215
8487	25.0063	49	1.959506204
8488	25.0061	32	1.279687756
8616	8.076	1	0.123823675

8617	25.0058	1	0.039990722
8746	3.0639	4	1.305525637
8747	24.1475	2	0.082824309
8877	9.4413	3	0.317752852
10183	10.7326	7	0.652218475
10184	25.002	2	0.079993601
10704	12.6047	8	0.634683888
10705	25.0023	8	0.319970563
10835	25.0014	2	0.07999552
10964	5.3231	9	1.690744115
10965	25.0015	5	0.199988001
10966	25.0012	1	0.03999808
11094	5.0405	13	2.579109215
11095	25.0009	13	0.519981281
11096	25.0007	4	0.15999552
11097	25	10	0.4
11224	0.9873	5	5.064316824
11225	23.5995	17	0.720354245
11226	25.0017	6	0.239983681
11228	24.9999	6	0.24000096
11355	17.8812	26	1.454041116
11356	25.0007	28	1.119968641
11357	25.0005	73	2.919941601
11358	24.9999	31	1.24000496
11485	12.9599	1	0.077161089
11486	25.0006	2	0.07999808
11487	25.0009	14	0.559979841
11614	0.5186	6	11.56961049
11615	21.4197	52	2.427671723
11616	25.001	29	1.159953602
11617	25.0008	44	1.759943682
11618	25.0002	6	0.23999808
11745	21.7338	10	0.46011282
11746	25.0014	11	0.439975361
11747	25.0007	56	2.239937282
11748	24.9995	17	0.6800136
11875	18.2752	1	0.054718963
11876	25.0012	32	1.279938563
11877	25.001	85	3.399864005
11878	25.0009	19	0.759972641
12007	24.9992	14	0.560017921
12008	24.9991	8	0.32001152
12648	0.4793	1	2.086375965
12777	13.3847	21	1.568955599
12778	17.639	7	0.396847894
12779	3.0933	6	1.939676074
12782	13.7883	6	0.435151542

12907	18.7689	11	0.586075902
12908	25.0069	27	1.079702002
12909	22.0596	4	0.181326951
12910	11.1634	1	0.089578444
12911	14.8928	2	0.134293081
12912	24.8568	1	0.04023044
13036	12.2852	38	3.093152737
13037	24.2937	15	0.617444029
13038	25.0049	55	2.199568884
13166	6.0572	28	4.6225979
13167	25.006	1	0.039990402
13168	25.0049	1	0.039992162
13296	10.3126	3	0.29090627
13298	25.0054	2	0.079982724
13426	3.7934	20	5.272315074
13427	25.006	7	0.279932816
13556	4.1863	6	1.433246542
13557	23.2366	3	0.129106668
13558	12.1899	1	0.082035127
13688	1.4103	4	2.83627597
13689	6.8791	36	5.233242721
13818	12.7823	9	0.704098636
13819	12.3663	8	0.64691945
13948	8.4143	2	0.237690598
13949	12.1061	15	1.239044779
14080	12.0446	1	0.083024758
14211	24.7803	1	0.040354637
14471	3.3882	4	1.180567853
14472	25.0028	20	0.79991041
14732	1.3887	2	1.440195867
14733	17.5789	2	0.113772762
14994	5.0275	3	0.596718051
14995	24.9206	6	0.240764669
15124	3.7741	1	0.264963832
15125	24.9694	5	0.2002451

Table A.8 Density of Archaeological Sites in 10x10-kilometre grid.

Density = number of sites/area

Grid5_id	Area	Number of Sites	Density
3008	22.39	69	3.081430
3138	12.76	51	3.996865
3268	2.18	14	6.434415
3269	24.63	107	4.344366
3399	19.15	90	4.698831
3529	11.53	26	2.254909
3659	6.73	24	3.566334
4050	6.31	36	5.702338
4180	4.11	29	7.063523
4181	25.01	66	2.638702
4701	0.73	6	8.165487
4962	2.60	21	8.069164
5223	14.91	52	3.487265
5353	3.83	19	4.960706
5614	10.42	29	2.783911
6005	8.14	17	2.088760
7310	6.82	28	4.105211
7440	0.33	23	70.769230
11094	5.04	13	2.579109
11224	0.99	5	5.064317
11357	25.00	73	2.919942
11614	0.52	6	11.569610
11615	21.42	52	2.427672
11747	25.00	56	2.239937
11877	25.00	85	3.399864
12648	0.48	1	2.086376
13036	12.29	38	3.093153
13038	25.00	55	2.199569
13166	6.06	28	4.622598
13426	3.79	20	5.272315
13688	1.41	4	2.836276
13689	6.88	36	5.233243

Table A.9 Squares with density values ≥ 1 Standard Deviation of the Mean.

Grid5_id	N*	S*	H	e	d	c
1311	2	1	0	0	0	1
3008	69	2	0.669328	0.965636	0.236177	0.523629
3138	51	2	0.683698	0.986368	0.254335	0.509419
3268	14	2	0.410116	0.591673	0.378923	0.755102
3269	107	3	0.904948	0.823719	0.428006	0.463709
3399	90	3	0.984952	0.896542	0.444463	0.404691
3529	26	1	0	0	0	1
3530	5	1	0	0	0	1
3659	24	1	0	0	0	1
3660	8	2	0.37677	0.543564	0.480898	0.78125
3790	7	1	0	0	0	1
3920	8	2	0.37677	0.543564	0.480898	0.78125
3921	6	3	1.011404	0.92062	1.116221	0.388889
4050	36	2	0.492604	0.710677	0.279055	0.686728
4051	11	2	0.474139	0.684038	0.417032	0.702479
4180	29	5	0.971429	0.603583	1.187897	0.543401
4181	66	5	1.080172	0.671148	0.954733	0.411387
4311	18	1	0	0	0	1
4441	30	1	0	0	0	1
4701	6	2	0.636514	0.918296	0.558111	0.555556
4702	37	2	0.342542	0.494183	0.276938	0.807159
4962	21	3	0.668018	0.608056	0.656917	0.619048
4963	27	2	0.675901	0.975119	0.303413	0.517147
5093	32	2	0.685314	0.988699	0.288539	0.507813
5223	52	3	0.616287	0.560968	0.50617	0.653107
5353	19	3	0.660579	0.601285	0.679247	0.645429
5354	10	1	0	0	0	1
5484	16	3	0.601924	0.547895	0.721348	0.679688
5614	29	2	0.250955	0.362051	0.296974	0.871581
5615	5	2	0.500402	0.721928	0.621335	0.68
5744	1	1	0	0	0	1
5875	5	1	0	0	0	1
6005	17	4	1.205698	0.869727	1.058868	0.32872
6006	2	1	0	0	0	1
6136	2	2	0.693147	1	1.442695	0.5
7310	28	1	0	0	0	1
7311	9	1	0	0	0	1
7440	23	1	0	0	0	1
7441	19	1	0	0	0	1
7571	3	1	0	0	0	1
8358	2	1	0.693147	0	0	0.5
8486	12	1	0	0	0	1
8487	49	2	0.59827	0.863121	0.256949	0.591837
8488	32	2	0.643492	0.928362	0.288539	0.548828
8616	1	1	0	0	0	1

8617	1	1	0	0	0	1
8746	4	1	0	0	0	1
8747	2	1	0	0	0	1
8877	3	1	0	0	0	1
10183	7	2	0.682908	0.985228	0.513898	0.510204
10184	2	1	0	0	0	1
10704	8	2	0.37677	0.543564	0.480898	0.78125
10705	8	4	1.073543	0.774397	1.442695	0.4375
10835	2	1	0	0	0	1
10964	9	3	0.683739	0.622366	0.910239	0.62963
10965	5	3	0.950271	0.864974	1.24267	0.44
10966	1	1	0	0	0	1
11094	13	1	0	0	0	1
11095	13	4	1.220282	0.880248	1.169614	0.325444
11096	4	3	1.039721	0.946395	1.442695	0.375
11097	10	4	1.279854	0.92322	1.302883	0.3
11224	5	2	0.673012	0.970951	0.621335	0.52
11225	17	6	1.630001	0.909721	1.764781	0.224913
11226	6	2	0.636514	0.918296	0.558111	0.555556
11228	6	3	1.011404	0.92062	1.116221	0.388889
11355	26	3	0.618977	0.563417	0.613855	0.671598
11356	28	5	0.707109	0.439352	1.200407	0.683673
11357	73	5	1.53297	0.952488	0.932301	0.225371
11358	31	4	1.192688	0.860343	0.87362	0.32154
11485	1	1	0	0	0	1
11486	2	1	0	0	0	1
11487	14	3	0.876006	0.797375	0.757846	0.459184
11614	6	4	1.242453	0.896241	1.674332	0.333333
11615	52	6	1.751546	0.977556	1.265424	0.178254
11616	29	5	1.43774	0.893318	1.187897	0.258026
11617	44	1	0	0	0	1
11618	6	1	0	0	0	1
11745	10	3	1.029653	0.937231	0.868589	0.38
11746	11	3	1.09006	0.992215	0.834065	0.338843
11747	56	5	1.101088	0.684144	0.993702	0.439413
11748	17	3	0.846366	0.770395	0.705912	0.474048
11875	1	1	0	0	0	1
11876	32	4	1.220172	0.880168	0.865617	0.322266
11877	85	3	1.035014	0.94211	0.450182	0.37827
11878	19	3	1.060119	0.964962	0.679247	0.357341
12007	14	3	1.078992	0.982141	0.757846	0.346939
12008	8	2	0.661563	0.954434	0.480898	0.53125
12648	1	1	0	0	0	1
12777	21	3	1.052923	0.958411	0.656917	0.365079
12778	7	2	0.59827	0.863121	0.513898	0.591837
12779	6	1	0	0	0	1
12782	6	1	0	0	0	1

12907	11	3	1.09006	0.992215	0.834065	0.338843
12908	27	2	0.158411	0.228538	0.303413	0.928669
12909	4	2	0.693147	1	0.721348	0.5
12910	1	1	0	0	0	1
12911	2	1	0	0	0	1
12912	1	1	0	0	0	1
13036	38	4	1.083848	0.781831	0.824723	0.386427
13037	15	3	0.927617	0.844354	0.738539	0.448889
13038	55	4	0.557535	0.402177	0.748628	0.716364
13166	28	3	0.900955	0.820085	0.600203	0.436224
13167	1	1	0	0	0	1
13168	1	1	0	0	0	1
13296	3	2	0.636514	0.918296	0.910239	0.555556
13298	2	1	0	0	0	1
13426	20	3	0.730588	0.66501	0.667616	0.595
13427	7	1	0	0	0	1
13556	6	1	0	0	0	1
13557	3	1	0	0	0	1
13558	1	1	0	0	0	1
13688	4	1	0	0	0	1
13689	36	2	0.214559	0.309543	0.279055	0.895062
13818	9	4	1.310784	0.945531	1.365359	0.283951
13819	8	2	0.661563	0.954434	0.480898	0.53125
13948	2	1	0	0	0	1
13949	15	3	0.803315	0.731209	0.738539	0.52
14080	1	1	0	0	0	1
14211	1	1	0	0	0	1
14471	4	1	0	0	0	1
14472	20	1	0	0	0	1
14732	2	2	0.693147	1	1.442695	0.5
14733	2	1	0	0	0	1
14994	3	1	0	0	0	1
14995	6	2	0.450561	0.650022	0.558111	0.722222
15124	1	1	0	0	0	1
15125	5	1	0	0	0	1

Table A.10 Diversity of Archaeological Sites in 5x5-kilometre grid.

N = number of archaeological sites

S = number of site types

H = index of general diversity = $-\sum(P_i \log_e P_i)$, where P_i is the proportion of the sample in the i th type

e = index of evenness = $H/\log_e S$

d = index of diversity = $(S-1)/\log_e N$

c = index of dominance = $\sum(n_i/N)^2 = \sum(P_i)^2$

Grid5_id	N*	S*	H	e	d	c
3008	69	2	0.669328	0.965636	0.236177	0.523629
3138	51	2	0.683698	0.986368	0.254335	0.509419
3269	107	3	0.904948	0.823719	0.428006	0.463709
3399	90	3	0.984952	0.896542	0.444463	0.404691
3921	6	3	1.011404	0.920620	1.116221	0.388889
4050	36	2	0.492604	0.710677	0.279055	0.686728
4180	29	5	0.971429	0.603583	1.187897	0.543401
4181	66	5	1.080172	0.671148	0.954733	0.411387
4701	6	2	0.636514	0.918296	0.558111	0.555556
4962	21	3	0.668018	0.608056	0.656917	0.619048
4963	27	2	0.675901	0.975119	0.303413	0.517147
5093	32	2	0.685314	0.988699	0.288539	0.507813
5223	52	3	0.616287	0.560968	0.506170	0.653107
5353	19	3	0.660579	0.601285	0.679247	0.645429
5484	16	3	0.601924	0.547895	0.721348	0.679688
5615	5	2	0.500402	0.721928	0.621335	0.680000
6005	17	4	1.205698	0.869727	1.058868	0.328720
6136	2	2	0.693147	1.000000	1.442695	0.500000
8358	2	1	0.693147	0.000000	0.000000	0.500000
8487	49	2	0.598270	0.863121	0.256949	0.591837
8488	32	2	0.643492	0.928362	0.288539	0.548828
10183	7	2	0.682908	0.985228	0.513898	0.510204
10705	8	4	1.073543	0.774397	1.442695	0.437500
10965	5	3	0.950271	0.864974	1.242670	0.440000
10964	9	3	0.683739	0.622366	0.910239	0.629630
11097	10	4	1.279854	0.923220	1.302883	0.300000
11096	4	3	1.039721	0.946395	1.442695	0.375000
11095	13	4	1.220282	0.880248	1.169614	0.325444
11228	6	3	1.011404	0.920620	1.116221	0.388889
11226	6	2	0.636514	0.918296	0.558111	0.555556
11225	17	6	1.630001	0.909721	1.764781	0.224913
11224	5	2	0.673012	0.970951	0.621335	0.520000
11358	31	4	1.192688	0.860343	0.873620	0.321540
11357	73	5	1.532970	0.952488	0.932301	0.225371
11356	28	5	0.707109	0.439352	1.200407	0.683673
11355	26	3	0.618977	0.563417	0.613855	0.671598
11487	14	3	0.876006	0.797375	0.757846	0.459184
11616	29	5	1.437740	0.893318	1.187897	0.258026
11615	52	6	1.751546	0.977556	1.265424	0.178254
11614	6	4	1.242453	0.896241	1.674332	0.333333
11748	17	3	0.846366	0.770395	0.705912	0.474048
11747	56	5	1.101088	0.684144	0.993702	0.439413
11746	11	3	1.090060	0.992215	0.834065	0.338843
11745	10	3	1.029653	0.937231	0.868589	0.380000
11878	19	3	1.060119	0.964962	0.679247	0.357341

11877	85	3	1.035014	0.942110	0.450182	0.378270
11876	32	4	1.220172	0.880168	0.865617	0.322266
12008	8	2	0.661563	0.954434	0.480898	0.531250
12007	14	3	1.078992	0.982141	0.757846	0.346939
12777	21	3	1.052923	0.958411	0.656917	0.365079
12778	7	2	0.598270	0.863121	0.513898	0.591837
12907	11	3	1.090060	0.992215	0.834065	0.338843
12909	4	2	0.693147	1.000000	0.721348	0.500000
13036	38	4	1.083848	0.781831	0.824723	0.386427
13037	15	3	0.927617	0.844354	0.738539	0.448889
13038	55	4	0.557535	0.402177	0.748628	0.716364
13166	28	3	0.900955	0.820085	0.600203	0.436224
13296	3	2	0.636514	0.918296	0.910239	0.555556
13426	20	3	0.730588	0.665010	0.667616	0.595000
13818	9	4	1.310784	0.945531	1.365359	0.283951
13819	8	2	0.661563	0.954434	0.480898	0.531250
13949	15	3	0.803315	0.731209	0.738539	0.520000
14732	2	2	0.693147	1.000000	1.442695	0.500000

Table A.11 Squares with diversity values ≥ 1 Standard Deviation of the Mean.

N = number of archaeological sites

S = number of site types

H = index of general diversity = $-\sum(P_i \log_e P_i)$, where P_i is the proportion of the sample in the i th type

e = index of evenness = $H/\log_e S$

d = index of diversity = $(S-1)/\log_e N$

c = index of dominance = $\sum(n_i/N)^2 = \sum(P_i)^2$

Grid5_id	N*	S*	H	e	d	c
1311	2	1	0	0	0	1
3008	69	3	0.151289	0.137709	0.472355	0.943289
3138	51	2	0.096509	0.139233	0.254335	0.961553
3268	14	1	0	0	0	1
3269	107	1	0	0	0	1
3399	90	2	0.061047	0.088072	0.222232	0.978025
3529	26	1	0	0	0	1
3530	5	1	0	0	0	1
3659	24	1	0	0	0	1
3660	8	2	0.37677	0.543564	0.480898	0.78125
3790	7	1	0	0	0	1
3920	8	1	0	0	0	1
3921	6	2	0.450561	0.650022	0.558111	0.722222
4050	36	1	0	0	0	1
4051	11	1	0	0	0	1
4180	29	1	0	0	0	1
4181	66	3	0.156798	0.142724	0.477366	0.940771
4311	18	1	0	0	0	1
4441	30	1	0	0	0	1
4701	6	1	0	0	0	1
4702	37	1	0	0	0	1
4962	21	1	0	0	0	1
4963	27	1	0	0	0	1
5093	32	1	0	0	0	1
5223	52	1	0	0	0	1
5353	19	1	0	0	0	1
5354	10	1	0	0	0	1
5484	16	1	0	0	0	1
5614	29	1	0	0	0	1
5615	5	2	0.673012	0.970951	0.621335	0.52
5744	1	1	0	0	0	1
5875	5	1	0	0	0	1
6005	17	1	0	0	0	1
6006	2	1	0	0	0	1
6136	2	1	0	0	0	1
7310	28	1	0	0	0	1
7311	9	1	0	0	0	1
7440	23	1	0	0	0	1
7441	19	1	0	0	0	1
7571	3	1	0	0	0	1
8358	2	1	0	0	0	1
8486	12	1	0	0	0	1
8487	14	1	0	0	0	1
8488	11	2	0.474139	0.684038	0.417032	0.702479
8616	36	1	0	0	0	1

8617	1	1	0	0	0	1
8746	25	2	0.43967	0.63431	0.310667	0.7312
8747	2	1	0	0	0	1
8877	3	1	0	0	0	1
10183	7	2	0.59827	0.863121	0.513898	0.591837
10184	2	2	0.693147	1	1.442695	0.5
10704	8	1	0	0	0	1
10705	8	1	0	0	0	1
10835	2	1	0	0	0	1
10964	9	1	0	0	0	1
10965	5	1	0	0	0	1
10966	1	1	0	0	0	1
11094	13	1	0	0	0	1
11095	13	1	0	0	0	1
11096	4	1	0	0	0	1
11097	10	2	0.325083	0.468996	0.434294	0.82
11224	5	1	0	0	0	1
11225	17	1	0	0	0	1
11226	6	1	0	0	0	1
11228	6	1	0	0	0	1
11355	26	1	0	0	0	1
11356	28	1	0	0	0	1
11357	73	2	0.072378	0.104419	0.233075	0.972978
11358	31	2	0.142506	0.205593	0.291207	0.937565
11485	1	1	0	0	0	1
11486	2	1	0	0	0	1
11487	14	1	0	0	0	1
11614	6	3	0.867563	0.78969	1.116221	0.5
11615	52	3	0.189683	0.172657	0.50617	0.925296
11616	29	1	0	0	0	1
11617	44	1	0	0	0	1
11618	6	1	0	0	0	1
11745	10	1	0	0	0	1
11746	11	1	0	0	0	1
11747	56	1	0	0	0	1
11748	17	1	0	0	0	1
11875	1	1	0	0	0	1
11876	32	2	0.139061	0.200622	0.288539	0.939453
11877	85	1	0	0	0	1
11878	19	1	0	0	0	1
12007	14	1	0	0	0	1
12008	8	1	0	0	0	1
12648	1	1	0	0	0	1
12777	21	2	0.191444	0.276195	0.328459	0.909297
12778	7	1	0	0	0	1
12779	6	1	0	0	0	1
12782	6	1	0	0	0	1

12907	11	1	0	0	0	1
12908	27	1	0	0	0	1
12909	4	2	0.562335	0.811278	0.721348	0.625
12910	1	1	0	0	0	1
12911	2	1	0	0	0	1
12912	1	1	0	0	0	1
13036	38	1	0	0	0	1
13037	15	1	0	0	0	1
13038	55	2	0.090876	0.131107	0.249543	0.964298
13166	28	2	0.154076	0.222285	0.300102	0.931122
13167	1	1	0	0	0	1
13168	1	1	0	0	0	1
13296	3	1	0	0	0	1
13298	2	1	0	0	0	1
13426	20	1	0	0	0	1
13427	7	2	0.410116	0.591673	0.513898	0.755102
13556	6	1	0	0	0	1
13557	3	1	0	0	0	1
13558	1	1	0	0	0	1
13688	4	1	0	0	0	1
13689	36	2	0.214559	0.309543	0.279055	0.895062
13818	9	1	0	0	0	1
13819	8	1	0	0	0	1
13948	2	1	0	0	0	1
13949	16	1	0	0	0	1
14080	1	1	0	0	0	1
14211	1	1	0	0	0	1
14471	4	1	0	0	0	1
14472	20	1	0	0	0	1
14732	2	1	0	0	0	1
14733	2	1	0	0	0	1
14994	3	1	0	0	0	1
14995	6	1	0	0	0	1
15124	1	1	0	0	0	1
15125	5	1	0	0	0	1

Table A.12 Cultural Diversity of Archaeological sites in 5x5-kilometre grid.

N = number of archaeological sites

S = number of cultural types

H = index of general diversity = $-\sum(P_i \log_e P_i)$, where P_i is the proportion of the sample in the i th type

e = index of evenness = $H/\log_e S$

d = index of diversity = $(S-1)/\log_e N$

c = index of dominance = $\sum(n_i/N)^2 = \sum(P_i)^2$

Grid5_id	N*	S*	H	e	d	c
3008	69	3	0.151289	0.137709	0.472355	0.943289
3138	51	2	0.096509	0.139233	0.254335	0.961553
3399	90	2	0.061047	0.088072	0.222232	0.978025
3660	8	2	0.376770	0.543564	0.480898	0.781250
3921	6	2	0.450561	0.650022	0.558111	0.722222
4181	66	3	0.156798	0.142724	0.477366	0.940771
5615	5	2	0.673012	0.970951	0.621335	0.520000
8488	11	2	0.474139	0.684038	0.417032	0.702479
8746	25	2	0.439670	0.634310	0.310667	0.731200
10184	2	2	0.693147	1.000000	1.442695	0.500000
10183	7	2	0.598270	0.863121	0.513898	0.591837
11097	10	2	0.325083	0.468996	0.434294	0.820000
11358	31	2	0.142506	0.205593	0.291207	0.937565
11357	73	2	0.072378	0.104419	0.233075	0.972978
11615	52	3	0.189683	0.172657	0.506170	0.925296
11614	6	3	0.867563	0.789690	1.116221	0.500000
11876	32	2	0.139061	0.200622	0.288539	0.939453
12777	21	2	0.191444	0.276195	0.328459	0.909297
12909	4	2	0.562335	0.811278	0.721348	0.625000
13038	55	2	0.090876	0.131107	0.249543	0.964298
13166	28	2	0.154076	0.222285	0.300102	0.931122
13427	7	2	0.410116	0.591673	0.513898	0.755102
13689	36	2	0.214559	0.309543	0.279055	0.895062

Table A.13 Squares with cultural diversity values ≥ 1 Standard Deviation of the Mean.

N = number of archaeological sites

S = number of cultural types

H = index of general diversity = $-\sum(P_i \log_e P_i)$, where P_i is the proportion of the sample in the i th type

e = index of evenness = $H/\log_e S$

d = index of diversity = $(S-1)/\log_e N$

c = index of dominance = $\sum(n_i/N)^2 = \sum (P_i)^2$

Grid10_id	COUNT	% Part 'high'	'low'	'medium'	'high'
135	3314	74.23	0	390	2460
199	2834	83.80	0	459	2375
200	192212	81.65	0	34838	156947
265	91554	88.89	1506	8664	81384
331	189967	53.06	1794	87088	100787
396	101248	82.84	1361	16012	83875
462	131412	75.06	727	31522	98644
527	27169	83.01	32	4585	22552
593	80339	87.83	291	9371	70558
658	27856	85.40	793	3269	23790
659	206683	51.08	643	100467	105573
724	136747	85.96	1084	18112	117551
789	31035	85.13	1440	3173	26420
855	169744	77.71	1721	35273	131908
920	108356	78.67	2033	20908	85245
985	41765	79.52	2387	6081	33213
1050	8585	84.96	692	598	7294
1181	65665	77.09	1358	13598	50618
1246	5367	82.19	423	532	4411
1247	198797	50.08	9257	89976	99564
1312	143352	82.91	1268	22998	118851
1377	64393	80.55	1731	10682	51866
1378	210969	43.20	9373	109970	91133
1442	3721	77.10	555	294	2869
1443	203945	52.35	10288	86490	106764
1508	110847	87.38	1179	12550	96857
1573	15935	76.03	542	3278	12115
1574	194419	43.57	1414	108014	84706
1639	100025	68.74	1139	29798	68759
1704	17905	91.26	358	1207	16340
1705	197480	47.65	4088	98667	94096
1770	95821	67.26	1119	29999	64451
1771	212612	45.57	3817	110923	96882
1835	14909	81.82	1004	1707	12198
1836	205608	60.17	1195	79887	123715
1901	96176	82.80	799	15638	79638
1966	3066	89.11	187	147	2732
1967	188016	64.67	3063	62367	121591
2032	87850	93.60	0	5502	82230
2097	2402	99.08	0	22	2380
2098	143958	65.63	290	48803	94481
2163	20184	85.73	543	2338	17303
2164	208679	44.50	5496	110326	92857
2229	97839	69.82	15	29367	68316
2294	1671	98.03	1	31	1638

2295	151335	47.29	1174	78588	71573
2687	36522	48.95	1653	16962	17877
2752	21740	51.40	1628	8937	11175
2753	216183	41.47	0	125021	89658
2817	2086	66.87	288	403	1395
2882	1122	53.48	362	160	600
3139	1181	56.73	141	199	670
3204	162657	51.33	3152	74670	83494
3205	79641	64.40	1051	25786	51286
3268	39668	71.98	2261	8732	28553
3333	30477	49.77	2357	12880	15167
3398	9258	54.77	871	3316	5071
3464	46054	55.13	2402	18263	25389

Table A.14 10x10-kilometre grid squares with 41.4 percent of their area flagged 'high'.

Grid5_id	COUNT	% Part 'high'	'low'	'medium'	'high'
660	3318	74.20	0	390	2462
661	27840	60.64	37	10422	16882
789	38788	79.26	0	7449	30743
790	51290	72.13	0	13760	36995
791	52172	59.74	277	20330	31170
918	2834	83.80	0	459	2375
919	51553	92.77	0	3230	47825
920	52205	79.29	0	10400	41392
921	52384	57.61	610	20997	30179
1049	18183	93.61	578	583	17022
1050	52170	86.05	186	6710	44894
1180	21631	89.96	787	1384	19460
1181	51951	64.06	69	18110	33281
1311	48896	74.02	691	11648	36193
1441	38361	77.29	858	7399	29649
1442	52379	55.31	0	22900	28972
1571	21354	82.43	807	2945	17602
1572	52305	84.54	0	7684	44221
1573	52422	49.84	0	25757	26125
1702	26857	79.86	551	4858	21448
1703	51922	77.00	23	11465	39981
1833	26574	90.75	345	2112	24117
1834	52462	54.30	0	23467	28487
1963	3046	91.83	24	225	2797
1964	49854	86.69	375	5705	43219
2094	27122	82.99	32	4581	22509
2095	52611	56.82	0	22095	29892
2225	21140	73.39	217	5408	15515
2355	62	62.90	4	19	39
2356	48137	83.86	219	7078	40370
2486	32750	91.95	68	2235	30113
2487	52643	49.76	0	25881	26193
2616	24451	90.48	695	1632	22124
2617	52607	71.37	0	14547	37547
2746	3420	48.74	115	1638	1667
2747	50407	78.83	648	10022	39737
2748	52111	53.04	0	24472	27639
2877	33062	91.40	542	2302	30218
2878	52756	74.94	0	12597	39536
3007	4901	91.31	241	185	4475
3008	47081	92.01	325	3035	43320
3138	26550	86.69	965	2570	23015
3139	52169	58.68	413	21145	30611
3268	4530	75.25	515	606	3409
3269	51375	69.64	563	15034	35778

3399	40427	78.76	1131	7004	31840
3400	52829	64.19	249	18082	33913
3529	24099	92.45	381	1438	22280
3530	52235	83.62	0	8558	43677
3659	14049	58.99	1161	4585	8287
3660	52261	91.96	0	4200	48061
3790	42201	68.39	789	12071	28860
3920	28497	75.15	1353	5728	21416
3921	52303	54.93	91	23481	28731
4050	13212	89.30	1060	354	11798
4051	52327	61.14	500	19832	31995
4180	8590	84.90	700	597	7293
4311	46180	52.65	855	20500	24315
4441	32665	75.03	822	7335	24508
4571	13483	73.69	1055	2455	9936
4701	1481	59.55	470	129	882
4702	46446	71.26	274	12698	33098
4832	18095	91.96	631	778	16640
4962	5380	82.01	432	536	4412
4963	52675	69.38	791	14782	36548
5093	41690	83.84	600	6139	34951
5094	52546	49.85	1618	24736	26192
5223	30869	89.85	753	2379	27737
5224	53157	73.78	0	13356	39217
5353	7909	90.88	205	516	7188
5354	51792	86.33	334	6745	44713
5484	42448	80.76	752	7414	34282
5485	52611	69.95	0	15808	36803
5614	21906	80.27	1038	3283	17585
5615	52611	75.25	0	13023	39588
5744	3759	76.32	595	295	2869
5745	52453	83.02	231	8675	43547
5875	45812	88.42	776	4529	40507
6005	16418	93.93	434	560	15421
6006	52737	86.97	140	6729	45868
6136	41394	85.87	581	5268	35545
6266	15701	77.18	466	3098	12118
6267	52764	62.34	0	19873	32891
6397	36229	70.90	828	9716	25685
6527	8436	90.48	211	592	7633
6528	51904	53.14	142	24181	27581
6658	39107	85.60	808	4822	33477
6788	17088	90.86	320	1214	15526
6789	53082	70.68	129	15185	37521
6918	781	93.85	48	0	733
6919	38380	82.99	498	6030	31852
7049	4261	48.53	547	1646	2068

7050	52091	61.29	137	20028	31926
7051	53117	53.09	0	24671	28199
7180	39266	77.33	471	8305	30364
7181	53158	62.42	0	19728	33183
7310	14305	81.78	909	1672	11699
7311	53010	74.33	0	13610	39400
7440	664	76.51	110	46	508
7441	45921	78.81	315	9414	36192
7442	53216	60.51	260	20508	32201
7571	14743	91.02	33	1291	13419
7572	52871	79.19	13	10762	41869
7702	28740	84.82	759	3603	24378
7703	53217	52.31	2659	22470	27840
7832	3038	89.30	192	133	2713
7833	50621	88.99	0	5379	45049
7963	30486	90.31	0	2953	27533
7964	53283	63.95	0	18961	34074
8093	5772	100.00	0	0	5772
8094	52481	89.46	0	5319	46952
8224	29685	99.38	0	183	29502
8225	53187	62.88	20	19475	33443
8354	2402	99.08	0	22	2380
8355	43643	73.52	0	11469	32088
8356	53093	55.62	0	23316	29529
8357	53511	62.43	0	19855	33407
8485	3267	97.73	0	74	3193
8486	43999	67.44	293	13906	29671
8616	16803	82.02	547	2340	13782
8617	53535	47.86	0	27666	25620
8746	3522	100.00	0	0	3522
8747	48990	60.16	0	19347	29474
8877	13963	88.76	0	1569	12394
8878	53444	58.54	0	21919	31288
9008	30576	80.57	15	5879	24634
9138	1673	97.97	1	33	1639
9139	42430	63.01	150	15442	26737
9271	53455	51.34	300	25463	27443
9270	48983	53.89	285	22154	26398
9269	6890	82.93	343	833	5714
9531	35251	53.29	1152	15098	18784
9661	8832	57.47	695	3061	5076
9792	20510	52.71	1176	8434	10811
9923	46380	51.11	684	21798	23706
10053	35817	55.48	705	15099	19870
10183	22749	66.45	910	6687	15116
10705	53810	46.46	0	28561	24998
10704	27148	56.56	891	10814	15354

10835	53854	53.13	0	24990	28613
10966	53863	59.73	0	21439	32173
10964	10983	49.89	784	4655	5479
11094	10881	52.35	872	4284	5696
11224	2106	66.24	307	404	1395
11356	53918	62.24	0	20108	33559
11485	27990	54.85	848	11656	15352
11614	1144	52.80	373	167	604
12006	53875	51.26	0	26258	27617
12648	1136	59.07	154	199	671
12782	30012	57.50	808	11727	17257
12777	29443	57.71	1142	10856	16993
12778	38670	69.29	1197	10174	26793
12779	6783	76.97	189	1259	5221
12907	40741	52.71	909	18162	21476
12910	24524	81.80	284	3673	20061
12909	47628	54.73	604	20704	26067
13036	26729	68.32	1505	6824	18261
13037	52837	50.13	81	26013	26489
13166	13202	78.12	851	1914	10314
13296	22287	51.93	1107	9568	11574
13556	9118	54.78	799	3324	4995
13687	20132	74.74	871	4214	15047
13689	14909	52.77	988	5996	7868
13818	27874	50.48	1388	12234	14072
13819	26781	60.51	1154	9316	16205
13948	18381	61.40	1070	6025	11286
14994	7673	63.76	559	2222	4892
16037	487	55.24	155	63	269

Table A.15 5x5-kilometre grid squares with 41.4 percent of their area flagged ‘high’.

APPENDIX B

EUROPEAN CONVENTION ON THE PROTECTION OF THE ARCHAEOLOGICAL HERITAGE (Revised)

Convention européenne pour la protection du patrimoine archéologique (révisée)

Valletta - La Valette, 16.1.1992

Entry into force:

Preamble

The member States of the Council of Europe and the other States party to the European Cultural Convention signatory hereto,

Considering that the aim of the Council of Europe is to achieve a greater unity between its members for the purpose, in particular, of safeguarding and realising the ideals and principles which are their common heritage;

Having regard to the European Cultural Convention signed in Paris on 19 December 1954, in particular Articles 1 and 5 thereof;

Having regard to the Convention for the Protection of the Architectural Heritage of Europe signed in Granada on 3 October 1985;

Having regard to the European Convention on Offences relating to Cultural Property signed in Delphi on 23 June 1985;

Having regard to the recommendations of the Parliamentary Assembly relating to archaeology and in particular Recommendations 848 (1978), 921 (1981) and 1072 (1988);

Having regard to Recommendation No. R (89) 5 concerning the protection and enhancement of the archaeological heritage in the context of town and country planning operations;

Recalling that the archaeological heritage is essential to a knowledge of the history of mankind;

Acknowledging that the European archaeological heritage, which provides evidence of ancient history, is seriously threatened with deterioration because of the increasing number of major planning schemes, natural risks, clandestine or unscientific excavations and insufficient public awareness;

Affirming that it is important to institute, where they do not yet exist, appropriate administrative and scientific supervision procedures, and that the need to protect the archaeological heritage should be reflected in town and country planning and cultural development policies;

Stressing that responsibility for the protection of the archaeological heritage should rest not only with the State directly concerned but with all European countries, the aim being to reduce the risk of deterioration and promote conservation by encouraging exchanges of experts and the comparison of experiences;

Noting the necessity to complete the principles set forth in the European Convention for the Protection of the Archaeological Heritage signed in London on 6 May 1969, as a result of evolution of planning policies in European countries,

Have agreed as follows:

Definition of the archaeological heritage

Article 1

The aim of this (revised) Convention is to protect the archaeological heritage as a source of the European collective memory and as an instrument for historical and scientific

study.

To this end shall be considered to be elements of the archaeological heritage all remains and objects and any other traces of mankind from past epochs:

- i. the preservation and study of which help to retrace the history of mankind and its relation with the natural environment;
- ii. for which excavations or discoveries and other methods of research into mankind and the related environment are the main sources of information; and
- iii. which are located in any area within the jurisdiction of the Parties.

The archaeological heritage shall include structures, constructions, groups of buildings, developed sites, moveable objects, monuments of other kinds as well as their context, whether situated on land or under water.

Identification of the heritage and measures for protection

Article 2

Each Party undertakes to institute, by means appropriate to the State in question, a legal system for the protection of the archaeological heritage, making provision for:

- i. the maintenance of an inventory of its archaeological heritage and the designation of protected monuments and areas;
- ii. the creation of archaeological reserves, even where there are no visible remains on the ground or under water, for the preservation of material evidence to be studied by later generations;
- iii. the mandatory reporting to the competent authorities by a finder of the chance discovery of elements of the archaeological heritage and making them available for examination.

Article 3

To preserve the archaeological heritage and guarantee the scientific significance of archaeological research work, each Party undertakes:

- i. to apply procedures for the authorisation and supervision of excavation and other archaeological activities in such a way as:
 - a. to prevent any illicit excavation or removal of elements of the archaeological heritage;
 - b. to ensure that archaeological excavations and prospecting are undertaken in a scientific manner and provided that:
 - non-destructive methods of investigation are applied wherever possible;
 - the elements of the archaeological heritage are not uncovered or left exposed during or after excavation without provision being made for their proper preservation, conservation and management;
- ii. to ensure that excavations and other potentially destructive techniques are carried out only by qualified, specially authorised persons;
- iii. to subject to specific prior authorisation, whenever foreseen by the domestic law of the State, the use of metal detectors and any other detection equipment or process for archaeological investigation.

Article 4

Each Party undertakes to implement measures for the physical protection of the archaeological heritage, making provision, as circumstances demand:

- i. for the acquisition or protection by other appropriate means by the public authorities of areas intended to constitute archaeological reserves;
- ii. for the conservation and maintenance of the archaeological heritage, preferably in situ;
- iii. for appropriate storage places for archaeological remains which have been removed from their original location.

Integrated conservation of the archaeological heritage

Article 5

Each Party undertakes:

- i. to seek to reconcile and combine the respective requirements of archaeology and development plans by ensuring that archaeologists participate:
 - a. in planning policies designed to ensure well-balanced strategies for the protection, conservation and enhancement of sites of archaeological interest;
 - b. in the various stages of development schemes;
- ii. to ensure that archaeologists, town and regional planners systematically consult one another in order to permit:
 - a. the modification of development plans likely to have adverse effects on the archaeological heritage;
 - b. the allocation of sufficient time and resources for an appropriate scientific study to be made of the site and for its findings to be published;
- iii. to ensure that environmental impact assessments and the resulting decisions involve full consideration of archaeological sites and their settings;
- iv. to make provision, when elements of the archaeological heritage have been found during development work, for their conservation in situ when feasible;
- v. to ensure that the opening of archaeological sites to the public, especially any structural arrangements necessary for the reception of large numbers of visitors, does not adversely affect the archaeological and scientific character of such sites and their surroundings.

The financing of archaeological research and conservation

Article 6

Each Party undertakes:

- i. to arrange for public financial support for archaeological research from national, regional and local authorities in accordance with their respective competence;
- ii. to increase the material resources for rescue archaeology:
 - a. by taking suitable measures to ensure that provision is made in major public or private development schemes for covering, from public sector or private sector resources, as appropriate, the total costs of any necessary related archaeological operations;
 - b. by making provision in the budget relating to these schemes in the same way as for the impact studies necessitated by environmental and regional planning

precautions, for preliminary archaeological study and prospection, for a scientific summary record as well as for the full publication and recording of the findings.

Collection and dissemination of scientific information

Article 7

For the purpose of facilitating the study of, and dissemination of knowledge about, archaeological discoveries, each Party undertakes:

- i. to make or bring up to date surveys, inventories and maps of archaeological sites in the areas within its jurisdiction;
- ii. to take all practical measures to ensure the drafting, following archaeological operations, of a publishable scientific summary record before the necessary comprehensive publication of specialised studies.

Article 8

Each Party undertakes:

- i. to facilitate the national and international exchange of elements of the archaeological heritage for professional scientific purposes, while taking appropriate steps to ensure that such circulation in no way prejudices the cultural and scientific value of those elements;
- ii. to promote the pooling of information on archaeological research and excavations in progress and to contribute to the organisation of international research programmes.

Promotion of public awareness

Article 9

Each Party undertakes:

- i. to conduct educational actions with a view to rousing and developing an awareness in public opinion of the value of the archaeological heritage for understanding the past and of the threats to this heritage;
- ii. to promote public access to important elements of its archaeological heritage, especially sites, and encourage the display to the public of suitable selections of archaeological objects.

Prevention of the illicit circulation of elements of the archaeological heritage

Article 10

Each Party undertakes:

- i. to arrange for the relevant public authorities and for scientific institutions to pool information on any illicit excavations identified;
- ii. to inform the competent authorities in the State of origin which is a Party to this Convention of any offer suspected of coming either from illicit excavations or unlawfully from official excavations, and to provide the necessary details thereof;
- iii. to take such steps as are necessary to ensure that museums and similar institutions whose acquisition policy is under State control do not acquire elements of the archaeological heritage suspected of coming from uncontrolled finds or illicit excavations or unlawfully from official excavations;
- iv. as regards museums and similar institutions located in the territory of a Party but

the acquisition policy of which is not under State control:

- a. to convey to them the text of this (revised) Convention;
- b. to spare no effort to ensure respect by the said museums and institutions for the principles set out in paragraph 3 above;
- v. to restrict, as far as possible, by education, information, vigilance and co-operation, the transfer of elements of the archaeological heritage obtained from uncontrolled finds or illicit excavations or unlawfully from official excavations.

Article 11

Nothing in this (revised) Convention shall affect existing or future bilateral or multilateral treaties between Parties concerning the illicit circulation of elements of the archaeological heritage or their restitution to the rightful owner.

Mutual technical and scientific assistance

Article 12

The Parties undertake:

- i. to afford mutual technical and scientific assistance through the pooling of experience and exchanges of experts in matters concerning the archaeological heritage;
- ii. to encourage, under the relevant national legislation or international agreements binding them, exchanges of specialists in the preservation of the archaeological heritage, including those responsible for further training.

Control of the application of the (revised) Convention

Article 13

For the purposes of this (revised) Convention, a committee of experts, set up by the Committee of Ministers of the Council of Europe pursuant to Article 17 of the Statute of the Council of Europe, shall monitor the application of the (revised) Convention and in particular:

- i. report periodically to the Committee of Ministers of the Council of Europe on the situation of archaeological heritage protection policies in the States Parties to the (revised) Convention and on the implementation of the principles embodied in the (revised) Convention;
- ii. propose measures to the Committee of Ministers of the Council of Europe for the implementation of the (revised) Convention's provisions, including multilateral activities, revision or amendment of the (revised) Convention and informing public opinion about the purpose of the (revised) Convention;
- iii. make recommendations to the Committee of Ministers of the Council of Europe regarding invitations to States which are not members of the Council of Europe to accede to the (revised) Convention.

Final clauses

Article 14

This (revised) Convention shall be open for signature by the member States of the Council of Europe and the other States party to the European Cultural Convention.

It is subject to ratification, acceptance or approval. Instruments of ratification, acceptance or approval shall be deposited with the Secretary General of the Council of Europe.

No State party to the European Convention on the Protection of the Archaeological Heritage, signed in London on 6 May 1969, may deposit its instrument of ratification, acceptance or approval unless it has already denounced the said convention or denounces it simultaneously.

This (revised) Convention shall enter into force six months after the date on which four States, including at least three member States of the Council of Europe, have expressed their consent to be bound by the (revised) Convention in accordance with the provisions of the preceding paragraphs.

Whenever, in application of the preceding two paragraphs, the denunciation of the convention of 6 May 1969 would not become effective simultaneously with the entry into force of this (revised) Convention, a Contracting State may, when depositing its instrument of ratification, acceptance or approval, declare that it will continue to apply the Convention of 6 May 1969 until the entry into force of this (revised) Convention.

In respect of any signatory State which subsequently expresses its consent to be bound by it, the (revised) Convention shall enter into force six months after the date of the deposit of the instrument of ratification, acceptance or approval.

Article 15

After the entry into force of this (revised) Convention, the Committee of Ministers of the Council of Europe may invite any other State not a member of the Council and the European Economic Community, to accede to this (revised) Convention by a decision taken by the majority provided for in Article 20.d of the Statute of the Council of Europe and by the unanimous vote of the representatives of the Contracting States entitled to sit on the Committee.

In respect of any acceding State or, should it accede, the European Economic Community, the (revised) Convention shall enter into force six months after the date of deposit of the instrument of accession with the Secretary General of the Council of Europe.

Article 16

Any State may, at the time of signature or when depositing its instrument of ratification, acceptance, approval or accession, specify the territory or territories to which this (revised) Convention shall apply.

Any State may at any later date, by a declaration addressed to the Secretary General of the Council of Europe, extend the application of this (revised) Convention to any other territory specified in the declaration. In respect of such territory the (revised) Convention shall enter into force six months after the date of receipt of such declaration by the Secretary General.

Any declaration made under the two preceding paragraphs may, in respect of any territory specified in such declaration, be withdrawn by a notification addressed to the Secretary General. The withdrawal shall become effective six months after the date of receipt of such notification by the Secretary General.

Article 17

Any Party may at any time denounce this (revised) Convention by means of a notification addressed to the Secretary General of the Council of Europe.

Such denunciation shall become effective six months following the date of receipt of such notification by the Secretary General.

Article 18

The Secretary General of the Council of Europe shall notify the member States of the Council of Europe, the other States party to the European Cultural Convention and any State or the European Economic Community which has acceded or has been invited to accede to this (revised) Convention of:

- i. any signature;
- ii. the deposit of any instrument of ratification, acceptance, approval or accession;
- iii. any date of entry into force of this (revised) Convention in accordance with Articles 14, 15 and 16;
- iv. any other act, notification or communication relating to this (revised) Convention.

In witness whereof the undersigned, being duly authorised thereto, have signed this (revised) Convention.

Done at Valletta, this 16th day of January 1992, in English and French, both texts being equally authentic, in a single copy which shall be deposited in the archives of the Council of Europe. The Secretary General of the Council of Europe shall transmit certified copies to each member State of the Council of Europe, to the other States party to the European Cultural Convention, and to any non-member State or the European Economic Community invited to accede to this (revised) Convention.

Recommendation Concerning the Preservation of Cultural Property Endangered by Public or Private Works

The General Conference of the United Nations Educational, Scientific and Cultural Organization, meeting in Paris from 15 October to 20 November 1968, at its fifteenth session,

Considering that contemporary civilization and its future evolution rest upon, among other elements, the cultural traditions of the peoples of the world, their creative force and their social and economic development,

Considering that cultural property is the product and witness of the different traditions and of the spiritual achievements of the past and thus is an essential element in the personality of the peoples of the world,

Considering that it is indispensable to preserve it as much as possible, according to its historical and artistic importance, so that the significance and message of cultural property become a part of the spirit of peoples who thereby may gain consciousness of their own dignity,

Considering that preserving cultural property and rendering it accessible constitute, in the spirit of the Declaration of the Principles of International Cultural Co-operation adopted on 4 November 1966 in the course of its fourteenth session, means of encouraging mutual understanding among peoples and thereby serve the cause of peace,

Considering also that the well-being of all peoples depends, inter alia, upon the existence of a favourable and stimulating environment and that the preservation of cultural property of all periods of history contributes directly to such an environment,

Recognizing, on the other hand, the role that industrialization, towards which world civilization is moving, plays in the development of peoples and their spiritual and national fulfilment,

Considering, however, that the prehistoric, protohistoric and historic monuments and remains, as well as numerous recent structures having artistic, historic or scientific importance are increasingly threatened by public and private works resulting from industrial development and urbanization,

Considering that it is the duty of governments to ensure the protection and the preservation of the cultural heritage of mankind, as much as to promote social and economic development,

Considering in consequence that it is urgent to harmonize the preservation of the cultural heritage with the changes which follow from social and economic development, making serious efforts to meet both requirements in a broad spirit of understanding, and with reference to appropriate planning,

Considering equally that adequate preservation and accessibility of cultural property constitute a major contribution to the social and economic development of countries and regions which possess such treasures of mankind by means of promoting national and international tourism,

Considering finally that the surest guarantee for the preservation of cultural property rests in the respect and the attachment felt for it by the people themselves, and persuaded that such feelings may be greatly strengthened by adequate measures carried out by Member States,

Having before it proposals concerning the preservation of cultural property endangered by public or private works, which constitute item 16 on the agenda of the session,

Having decided at its thirteenth session that proposals on this item should be the subject of an international instrument in the form of a recommendation to Member States,

Adopts on this nineteenth day of November 1968 this recommendation.

The General Conference recommends that Member States should apply the following provisions by taking whatever legislative or other steps may be required to give effect within their respective territories to the norms and principles set forth in this recommendation.

The General Conference recommends that Member States should bring this recommendation to the attention of the authorities or services responsible for public or private works as well as to the bodies responsible for the conservation and the protection of monuments and historic, artistic, archaeological and scientific sites. It recommends that authorities and bodies which plan programmes for education and the development of tourism be equally informed.

The General Conference recommends that Member States should report to it, on the dates and in a manner to be determined by it, on the action they have taken to give effect to this recommendation.

I. Definition

1. For the purpose of this recommendation, the term 'cultural property' applies to:

(a) Immovables, such as archaeological and historic or scientific sites, structures or other features of historic, scientific, artistic or architectural value, whether religious or secular, including groups of traditional structures, historic quarters in urban or rural built-up areas and the ethnological structures of previous cultures still extant in valid form. It applies to such immovables constituting ruins existing above the earth as well as to archaeological or historic remains found within the earth. The term cultural property also includes the setting of such property;

(b) Movable property of cultural importance including that existing in or recovered from immovable property and that concealed in the earth, which may be found in archaeological or historical sites or elsewhere.

2. The term 'cultural property' includes not only the established and scheduled architectural, archaeological and historic sites and structure, but also the unscheduled or unclassified vestiges of the past as well as artistically or historically important recent sites and structures.

II. General principles

3. Measures to preserve cultural property should extend to the whole territory of the State and should not be confined to certain monuments and sites.

4. Protective inventories of important cultural property, whether scheduled or unscheduled, should be maintained. Where such inventories do not exist, priority should be given in their establishment to the thorough survey of cultural property in areas where such property is endangered by public or private works.

5. Due account should be taken of the relative significance of the cultural property concerned when determining measures required for the:

(a) Preservation of an entire site, structure, or other forms of immovable cultural property from the effects of private or public works;

(b) Salvage or rescue of cultural property if the area in which it is found is to be transformed by public or private works, and the whole or a part of the property in question is to be preserved and removed.

6. Measures should vary according to the character, size and location of the cultural property and the nature of the dangers with which it is threatened.

7. Measures for the preservation or salvage of cultural property should be preventive and corrective.

8. Preventive and corrective measures should be aimed at protecting or saving cultural property from public or private works likely to damage and destroy it, such as:

(a) Urban expansion and renewal projects, although they may retain scheduled monuments while sometimes removing less important structures, with the result that historical relations and the setting of historic quarters are destroyed;

(b) Similar projects in areas where groups of traditional structures having cultural value as a whole risk being destroyed for the lack of a scheduled individual monument;

(c) Injudicious modifications and repair of individual historic buildings;

(d) The construction or alteration of highways which are a particular danger to sites or to historically important structures or groups of structures;

(e) The construction of dams for irrigation, hydroelectric power or flood control;

(f) The construction of pipelines and of power and transmission lines of electricity;

(g) Farming operations including deep ploughing, drainage and irrigation operations, the clearing and levelling of land and afforestation;

(h) Works required by the growth of industry and the technological progress of industrialized societies such as airfields, mining and quarrying operations and dredging and reclamation of channels and harbours.

9. Member States should give due priority to measures required for the preservation in situ of cultural property endangered by public or private works in order to preserve historical associations and continuity. When overriding economic or social conditions require that cultural property be transferred, abandoned or destroyed, the salvage or rescue operations should always include careful study of the cultural property involved and the preparations of detailed records.

10. The results of studies having scientific or historic value carried out in connexion with salvage operations, particularly when all or much of the immovable cultural property has been abandoned or destroyed, should be published or otherwise made available for future research.

11. Important structures and other monuments which have been transferred in order to save them from destruction by public or private works should be placed on a site or in a setting which resembles their former position and natural, historic or artistic associations.

12. Important movable cultural property, including representative samples of objects recovered from archaeological excavations, obtained from salvage operations should be preserved for study or placed on exhibition in institutions such as museums including site museums, or universities.

III. Preservation and salvage measures

13. The preservation or salvage of cultural property endangered by public or private works should be ensured through the means mentioned below the precise measures to be determined by the legislation and organizational system of the State:

- (a) Legislation;
- (b) Finance;
- (c) Administrative measures;
- (d) Procedures to preserve and to salvage cultural property;
- (e) Penalties;
- (f) Repairs;
- (g) Awards;
- (h) Advice;
- (i) Educational programmes.

Legislation

14. Member States should enact or maintain on the national as well as on the local level the legislative measures necessary to ensure the preservation or salvage of cultural property endangered by public or private works in accordance with the norms and principles embodied in this recommendation.

Finance

15. Member States should ensure that adequate budgets are available for the preservation or salvage of cultural property endangered by public or private works. Although differences in legal systems and traditions as well as disparity in resources preclude the adoption of uniform measures, the following should be considered:

- (a) The national or local authorities responsible for the safeguarding of cultural property should have adequate budgets to undertake the preservation or salvage of cultural property endangered by public or private works; or
- (b) The costs of preserving or salvaging cultural property endangered by public or private works including preliminary archaeological research should form part of the budget of construction costs; or
- (c) The possibility of combining the two methods mentioned in subparagraphs a and b above should be provided for.

16. In the event of unusual costs due to the size and complexity of the operations required, there should be possibilities of obtaining additional funds through enabling legislation, special subventions, a national fund for monuments or other appropriate means. The services responsible for the safeguarding of cultural property should be empowered to administer or to utilize these extra-budgetary contributions required for the preservation or salvage of cultural property endangered by public or private works.

17. Member States should encourage proprietors of artistically or historically important structures, including structures forming part of a traditional group, or residents in a historic quarter in urban or rural built-up areas to preserve the character and aesthetic qualities of their cultural property, which would otherwise be endangered by public or private works, through:

- (a) Favourable tax rates; or
- (b) The establishment, through appropriate legislation, of a budget to assist, by grants, loans or other measures, local authorities, institutions and private owners of artistically, architecturally, scientifically or historically important structures including groups of traditional structures to maintain or to adapt them suitably for functions which would meet the needs of contemporary society; or
- (c) The possibility of combining the two methods mentioned in subparagraphs a and b above should be provided for.

18. If the cultural property is not scheduled or otherwise protected it should be possible for the owner to request such assistance from the appropriate authorities.

19. National or local authorities, as well as private owners, when budgeting for the preservation of cultural property endangered by public or private works, should take into account the intrinsic value of cultural property and also the contribution it can make to the economy as a tourist attraction.

Administrative measures

20. Responsibility for the preservation or salvage of cultural property endangered by public or private works should be entrusted to appropriate official bodies. Whenever official bodies or services already exist for the protection of cultural property, these bodies or services should be given responsibility for the preservation of cultural property against the dangers caused by public or private works. If such services do not exist, special bodies or services should be created for the purpose of the preservation of cultural property endangered by public or private works; and although differences of constitutional provisions and traditions preclude the adoption of a uniform system, certain common principles should be adopted.

(a) There should be a co-ordinating or consultative body, composed of representatives of the authorities responsible for the safeguarding of cultural property, for public and private works, for town planning, and of research and educational institutions, which should be competent to advise of the preservation of cultural property endangered by public or private works and, in particular, on conflicts of interest between requirements for public or private works and the preservation or salvage of cultural property.

b) Provincial, municipal or other forms of local government should also have services responsible for the preservation or salvage of cultural property endangered by public or private works. These services should be able to call upon the assistance of national services or other appropriate bodies in accordance with their capabilities and requirements.

(c) The services responsible for the safeguarding of cultural property should be adequately staffed with the specialists required for the preservation or salvage of cultural property endangered by public or private works, such as architects, urbanists, archaeologists, historians, inspectors and other specialists and technicians.

(d) Administrative measures should be taken to co-ordinate the work of the different services responsible for the safeguarding of cultural property with that of other services responsible for public and private works and that of any other department or service whose responsibilities touch upon the problem of the preservation or salvage of cultural property endangered by public or private works.

(e) Administrative measures should be taken to establish an authority or commission in charge of urban development programmes in all communities having scheduled or unscheduled historic quarters, sites and monuments which need to be preserved against public and private construction.

21. At the preliminary survey stage of any project involving construction in a locality recognized as being of cultural interest or likely to contain objects of archaeological or historical importance, several variants of the project should be prepared, at regional or municipal level, before a decision is taken. The choice between these variants should be made on the basis of a comprehensive comparative analysis, in order that the most advantageous solution, both economically and from the point of view of preserving or salvaging cultural property, may be adopted.

Procedures to preserve and to salvage cultural property

22. Thorough surveys should be carried out well in advance of any public or private works which might endanger cultural property to determine:

(a) The measures to be taken to preserve important cultural property in situ;

(b) The amount of salvage operations which would be required such as the selection of archaeological sites to be excavated, structures to be transferred and movable cultural property salvaged, etc.

23. Measures for the preservation or salvage of cultural property should be carried out well in advance of public or private works. In areas of archaeological or cultural importance, such as historic towns, villages, sites and districts, which should be protected by the legislation of every country, the starting of new work should be made conditional upon the execution of preliminary archaeological excavations. If necessary, work should be delayed to ensure that adequate measures are taken for the preservation or salvage of the cultural property concerned.

24. Important archaeological sites, and, in particular, prehistoric sites as they are difficult to recognize, historic quarters in urban or rural areas, groups of traditional structures, ethnological structures of previous cultures and other immovable cultural property which would otherwise be endangered by public or private works should be protected by zoning or scheduling:

(a) Archaeological reserves should be zoned or scheduled and, if necessary, immovable property purchased, to permit thorough excavation or the preservation of the ruins found at the site.

(b) Historic quarters in urban or rural centres and groups of traditional structures should be zoned and appropriate regulations adopted to preserve their setting and character, such as the imposition of controls on the degree to which historically or artistically important structures can be renovated and the type and design of new structures which can be introduced. The preservation of monuments should be an absolute requirement of any well-designed plan for urban redevelopment especially in historic cities or districts. Similar regulations should cover the area surrounding a scheduled monument or site and its setting to preserve its association and character. Due allowance should be made for the modification of ordinary regulations applicable to new construction; these should be placed in abeyance when new structures are introduced into an historical zone. Ordinary types of commercial advertising by means of posters and illuminated announcements should be forbidden, but commercial establishments could be allowed to indicate their presence by means of judiciously presented signs.

25. Member States should make it obligatory for persons finding archaeological remains in the course of public or private works to declare them at the earliest possible moment to the competent service. Careful examination should be carried out by the service concerned and, if the site is important, construction should be deferred to permit thorough excavation, due allowance or compensation being made for the delays incurred.

26. Member States should have provisions for the acquisition, through purchase, by national or local governments and other appropriate bodies of important cultural property endangered by public or private works. When necessary, it should be possible to effect such acquisition through expropriation.

Penalties

27. Member States should take steps to ensure that offences, through intent or negligence, against the preservation or salvage of cultural property endangered by public or private works are severely punished by their Penal Code, which should provide for fines or imprisonment or both.

In addition, the following measures could be applied:

a) Whenever possible, restoration of the site or structure at the expense of those responsible for the damage to it:

(b) In the case of a chance archaeological find, payment of damages to the State when immovable cultural property has been damaged, destroyed or

neglected: confiscation without compensation when a movable object has been concealed.

Repairs

28. Member States should, when the nature of the property so allows, adopt the necessary measures to ensure the repair, restoration or reconstruction of cultural property damaged by public or private works. They should also foresee the possibility of requiring local authorities and private owners of important cultural property to carry out repairs or restorations, with technical and financial assistance if necessary.

Awards

29. Member States should encourage individuals, associations and municipalities to take part in programmes for the preservation or salvage of cultural property endangered by public or private works. Measures to that effect could include:

(a) Ex gratia payments to individuals reporting or surrendering hidden archaeological finds;

(b) Awards of certificates, medals or other forms of recognition to individuals, even if they belong to government service associations, institutions or municipalities which have carried out outstanding projects for the preservation or salvage of cultural property endangered by public or private works.

Advice

30. Member States should provide individuals associations or municipalities lacking the required experience or staff with technical advice or supervision to maintain adequate standards for the preservation or salvage of cultural property endangered by public or private works.

Educational programmes

31. In a spirit of international collaboration, Member States should take steps to stimulate and develop among their nationals interest in, and respect for, the cultural heritage of the past of their own and other traditions in order to preserve or to salvage cultural property endangered by public or private works.

32. Specialized publications, articles in the press, and radio and television broadcasts should publicize the nature of the dangers to cultural property arising from ill-conceived public or private works as well as cases where cultural property has been successfully preserved or salvaged.

33. Educational institutions, historical and cultural associations, public bodies concerned with the tourist industry and associations for popular education should have programmes to publicize the dangers to cultural property arising from short-sighted public or private works and to underline the fact that projects to preserve cultural property contribute to international understanding.

34. Museums and educational institutions and other interested organizations should prepare special exhibitions on the dangers to cultural property arising from uncontrolled public or private works and on the measures which have been used to preserve or to salvage cultural property which has been endangered.

The foregoing is the authentic text of the recommendation duly adopted by the General Conference of the United Nations Educational, Scientific and Cultural Organization during its fifteenth session, which was held in Paris and declared closed the twentieth day of November 1968.

IN FAITH WHEREOF we have appended our signatures this twenty-second day of

November 1968.

The President of General Conference

The Director-General

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Archaeological Heritage Management

ICOMOS Charter for the Protection and Management of the Archaeological Heritage (1990)

Introduction

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INTRODUCTION

It is widely recognized that a knowledge and understanding of the origins and development of human societies is of fundamental importance to humanity in identifying its cultural and social roots.

The archaeological heritage constitutes the basic record of past human activities. Its protection and proper management is therefore essential to enable archaeologists and other scholars to study and interpret it on behalf of and for the benefit of present and future generations.

The protection of this heritage cannot be based upon the application of archaeological techniques alone. It requires a wider basis of professional and scientific knowledge and skills. Some elements of the archaeological heritage are components of architectural structures and in such cases must be protected in accordance with the criteria for the protection of such structures laid down in the 1966 Venice Charter on the Conservation and Restoration of Monuments and Sites. Other elements of the archaeological heritage constitute part of the living traditions of indigenous peoples, and for such sites and monuments the participation of local cultural groups is essential for their protection and preservation.

For these and other reasons the protection of the archaeological heritage must be based upon effective collaboration between professionals from many disciplines. It also requires the cooperation of government authorities, academic researchers, private or public enterprise, and the general public. This charter therefore lays down principles relating to the different aspects of archaeological heritage management. These include the responsibilities of public authorities and legislators, principles relating to the professional performance of the processes of inventorization, survey, excavation, documentation, research, maintenance, conservation, preservation, reconstruction, information, presentation, public access and use of the heritage, and the qualification of professionals involved in the protection of the archaeological heritage.

The charter has been inspired by the success of the Venice Charter as guidelines and source of ideas for policies and practice of governments as well as scholars and professionals.

The charter has to reflect very basic principles and guidelines with global validity. For this reason it cannot take into account the specific problems and possibilities of regions or countries. The charter should therefore be supplemented at regional and national levels by further principles and guidelines for these needs.

ARTICLE 1. DEFINITION AND INTRODUCTION

The "archaeological heritage" is that part of the material heritage in respect of which archaeological methods provide primary information. It comprises all vestiges of human

existence and consists of places relating to all manifestations of human activity, abandoned structures, and remains of all kinds (including subterranean and underwater sites), together with all the portable cultural material associated with them.

ARTICLE 2. INTEGRATED PROTECTION POLICIES

The archaeological heritage is a fragile and non-renewable cultural resource. Land use must therefore be controlled and developed in order to minimize the destruction of the archaeological heritage.

Policies for the protection of the archaeological heritage should constitute an integral component of policies relating to land use, development, and planning as well as of cultural, environmental and educational policies. The policies for the protection of the archaeological heritage should be kept under continual review, so that they stay up to date. The creation of archaeological reserves should form part of such policies.

The protection of the archaeological heritage should be integrated into planning policies at international, national, regional and local levels.

Active participation by the general public must form part of policies for the protection of the archaeological heritage. This is essential where the heritage of indigenous peoples is involved. Participation must be based upon access to the knowledge necessary for decision-making. The provision of information to the general public is therefore an important element in integrated protection.

ARTICLE 3. LEGISLATION AND ECONOMY

The protection of the archaeological heritage should be considered as a moral obligation upon all human beings; it is also a collective public responsibility. This obligation must be acknowledged through relevant legislation and the provision of adequate funds for the supporting programmes necessary for effective heritage management.

The archaeological heritage is common to all human society and it should therefore be the duty of every country to ensure that adequate funds are available for its protection.

Legislation should afford protection to the archaeological heritage that is appropriate to the needs, history, and traditions of each country and region, providing for in situ protection and research needs.

Legislation should be based on the concept of the archaeological heritage as the heritage of all humanity and of groups of peoples, and not restricted to any individual person or nation.

Legislation should forbid the destruction, degradation or alteration through changes of any archaeological site or monument or to their surroundings without the consent of the relevant archaeological authority.

Legislation should in principle require full archaeological investigation and documentation in cases where the destruction of the archaeological heritage is authorized.

Legislation should require, and make provision for, the proper maintenance, management and conservation of the archaeological heritage. Adequate legal sanctions should be prescribed in respect of violations of archaeological heritage legislation.

If legislation affords protection only to those elements of the archaeological heritage which are registered in a selective statutory inventory, provision should be made for the temporary protection of unprotected or newly discovered sites and monuments until an archaeological evaluation can be carried out.

Development projects constitute one of the greatest physical threats to the archaeological heritage. A duty for developers to ensure that archaeological heritage impact studies are carried out before development schemes are implemented, should therefore be embodied in appropriate legislation, with a stipulation that the costs of such studies are to be included in project costs. The principle should also be established in legislation that

development schemes should be designed in such a way as to minimize their impact upon the archaeological heritage.

ARTICLE 4. SURVEY

The protection of the archaeological heritage must be based upon the fullest possible knowledge of its extent and nature. General survey of archaeological resources is therefore an essential working tool in developing strategies for the protection of the archaeological heritage. Consequently archaeological survey should be a basic obligation in the protection and management of the archaeological heritage.

At the same time, inventories constitute primary resource databases for scientific study and research. The compilation of inventories should therefore be regarded as a continuous, dynamic process. It follows that inventories should comprise information at various levels of significance and reliability, since even superficial knowledge can form the starting point for protectional measures.

ARTICLE 5. INVESTIGATION

Archaeological knowledge is based principally on the scientific investigation of the archaeological heritage. Such investigation embraces the whole range of methods from non-destructive techniques through sampling to total excavation.

It must be an overriding principle that the gathering of information about the archaeological heritage should not destroy any more archaeological evidence than is necessary for the protectional or scientific objectives of the investigation. Non-destructive techniques, aerial and ground survey, and sampling should therefore be encouraged wherever possible, in preference to total excavation.

As excavation always implies the necessity of making a selection of evidence to be documented and preserved at the cost of losing other information and possibly even the total destruction of the monument, a decision to excavate should only be taken after thorough consideration.

Excavation should be carried out on sites and monuments threatened by development, land-use change, looting, or natural deterioration.

In exceptional cases, unthreatened sites may be excavated to elucidate research problems or to interpret them more effectively for the purpose of presenting them to the public. In such cases excavation must be preceded by thorough scientific evaluation of the significance of the site. Excavation should be partial, leaving a portion undisturbed for future research.

A report conforming to an agreed standard should be made available to the scientific community and should be incorporated in the relevant inventory within a reasonable period after the conclusion of the excavation.

Excavations should be conducted in accordance with the principles embodied in the 1956 UNESCO Recommendations on International Principles Applicable to Archaeological Excavations and with agreed international and national professional standards.

ARTICLE 6. MAINTENANCE AND CONSERVATION

The overall objective of archaeological heritage management should be the preservation of monuments and sites in situ, including proper long-term conservation and curation of all related records and collections etc. Any transfer of elements of the heritage to new locations represents a violation of the principle of preserving the heritage in its original context. This principle stresses the need for proper maintenance, conservation and management. It also asserts the principle that the archaeological heritage should not be exposed by excavation or left exposed after excavation if provision for its proper maintenance and management after excavation cannot be guaranteed.

Local commitment and participation should be actively sought and encouraged as a means of promoting the maintenance of the archaeological heritage. This principle is especially

important when dealing with the heritage of indigenous peoples or local cultural groups. In some cases it may be appropriate to entrust responsibility for the protection and management of sites and monuments to indigenous peoples.

Owing to the inevitable limitations of available resources, active maintenance will have to be carried out on a selective basis. It should therefore be applied to a sample of the diversity of sites and monuments, based upon a scientific assessment of their significance and representative character, and not confined to the more notable and visually attractive monuments.

The relevant principles of the 1956 UNESCO Recommendations should be applied in respect of the maintenance and conservation of the archaeological heritage.

ARTICLE 7. PRESENTATION, INFORMATION, RECONSTRUCTION

The presentation of the archaeological heritage to the general public is an essential method of promoting an understanding of the origins and development of modern societies. At the same time it is the most important means of promoting an understanding of the need for its protection.

Presentation and information should be conceived as a popular interpretation of the current state of knowledge, and it must therefore be revised frequently. It should take account of the multifaceted approaches to an understanding of the past.

Reconstructions serve two important functions: experimental research and interpretation. They should, however, be carried out with great caution, so as to avoid disturbing any surviving archaeological evidence, and they should take account of evidence from all sources in order to achieve authenticity. Where possible and appropriate, reconstructions should not be built immediately on the archaeological remains, and should be identifiable as such.

ARTICLE 8. PROFESSIONAL QUALIFICATIONS

High academic standards in many different disciplines are essential in the management of the archaeological heritage. The training of an adequate number of qualified professionals in the relevant fields of expertise should therefore be an important objective for the educational policies in every country. The need to develop expertise in certain highly specialized fields calls for international cooperation. Standards of professional training and professional conduct should be established and maintained.

The objective of academic archaeological training should take account of the shift in conservation policies from excavation to in situ preservation. It should also take into account the fact that the study of the history of indigenous peoples is as important in preserving and understanding the archaeological heritage as the study of outstanding monuments and sites.

The protection of the archaeological heritage is a process of continuous dynamic development. Time should therefore be made available to professionals working in this field to enable them to update their knowledge. Postgraduate training programmes should be developed with special emphasis on the protection and management of the archaeological heritage.

ARTICLE 9. INTERNATIONAL COOPERATION

The archaeological heritage is the common heritage of all humanity. International cooperation is therefore essential in developing and maintaining standards in its management.

There is an urgent need to create international mechanisms for the exchange of information and experience among professionals dealing with archaeological heritage management. This requires the organization of conferences, seminars, workshops, etc. at global as well as regional levels, and the establishment of regional centres for postgraduate studies. ICOMOS, through its specialized groups, should promote this aspect in its medium- and long-term planning.

International exchanges of professional staff should also be developed as a means of raising standards of archaeological heritage management.

Technical assistance programmes in the field of archaeological heritage management should be developed under the auspices of ICOMOS.

This Charter, written by the International Committee on Archaeological Heritage Management (ICAHM), a specialized committee of ICOMOS, was approved by the ICOMOS General Assembly, meeting in Lausanne, Switzerland, in October 1990.

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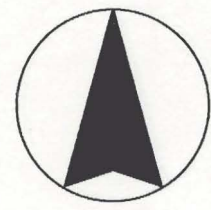
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17°30'



30°

Archaeological Sites

- × ESA
- × LSA
- × LSA/MSA
- × LSA/MSA/ESA
- × MSA
- × MSA/ESA
- Study Area

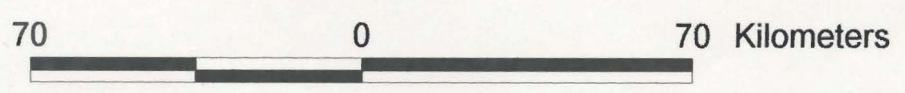
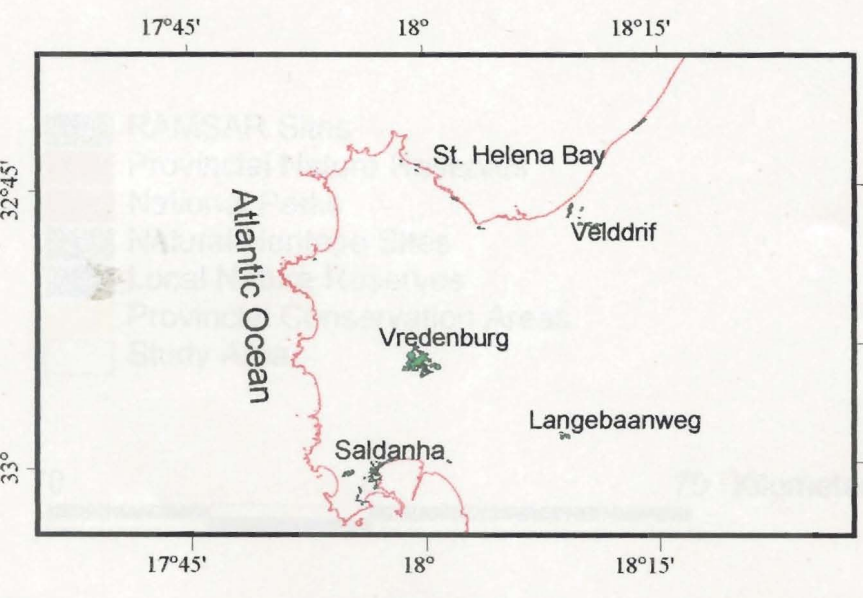
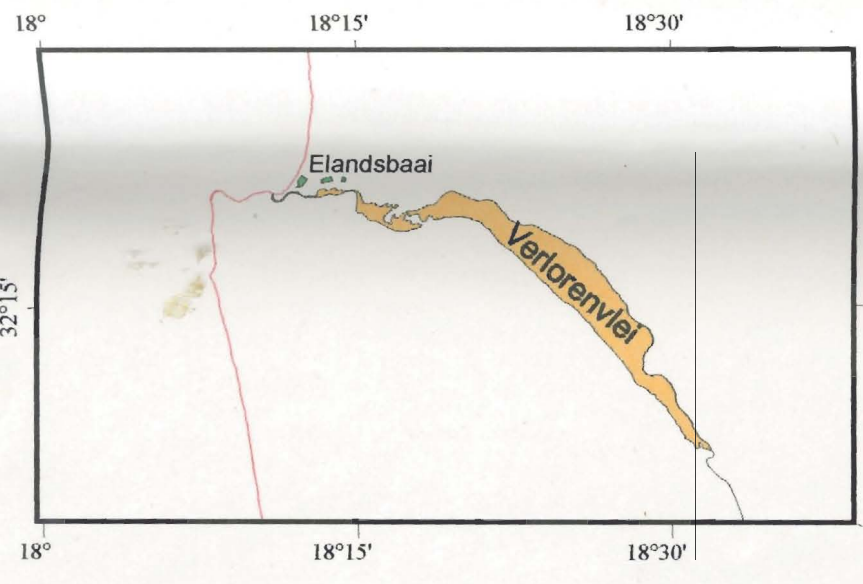
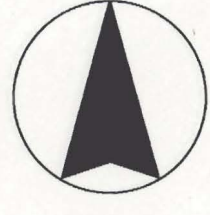
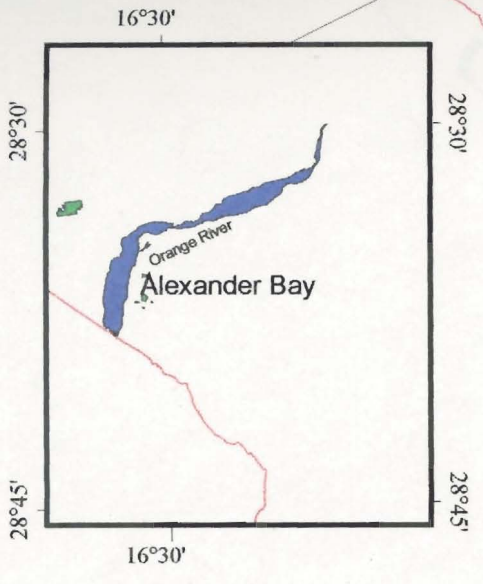
70 0 70 Kilometers

32°30'

Map 1. Study Area.

17°30'

17°30'

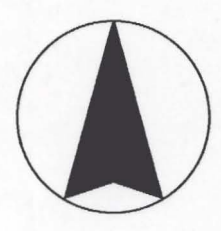


Map 2. Built-up Areas.

17°30'

30°

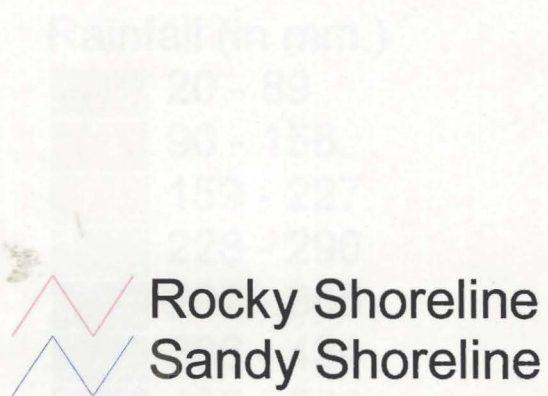
32°30'



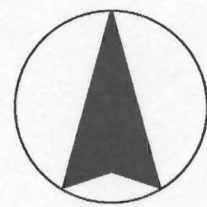
- RAMSAR Sites
- Provincial Nature Reserves
- National Parks
- Natural Heritage Sites
- Local Nature Reserves
- Provincial Conservation Areas
- Study Area



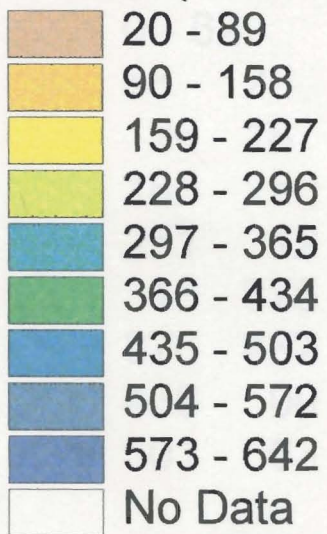
Map 3. Protected Locales.



Map 4. Sandy and Rocky Shoreline.



Rainfall (in mm.)



Map 5. Annual Precipitation.

17°30'



DEM (in meters)

	0 - 62
	63 - 125
	126 - 187
	188 - 250
	251 - 312
	313 - 375
	376 - 437
	438 - 500
	501 - 563
	No Data

70 0 70 Kilometers

A horizontal scale bar with a central zero point and markings for 70 kilometers on both sides.

Map 6. Digital Elevation Model.

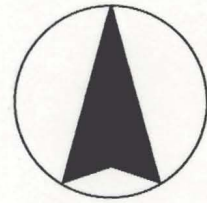
30°

30°

32°30'

32°30'

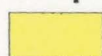
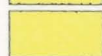
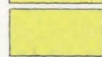







17°30'



30°

32°30'

Slope

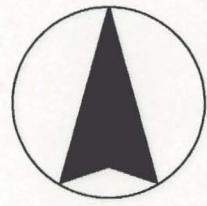
-  0 - 9.925
-  9.925 - 19.85
-  19.85 - 29.775
-  29.775 - 39.7
-  39.7 - 49.625
-  49.625 - 59.55
-  59.55 - 69.475
-  69.475 - 79.4
-  79.4 - 89.326
-  No Data

70 0 70 Kilometers



Map 7. Slope of the Study Area.

17°30'

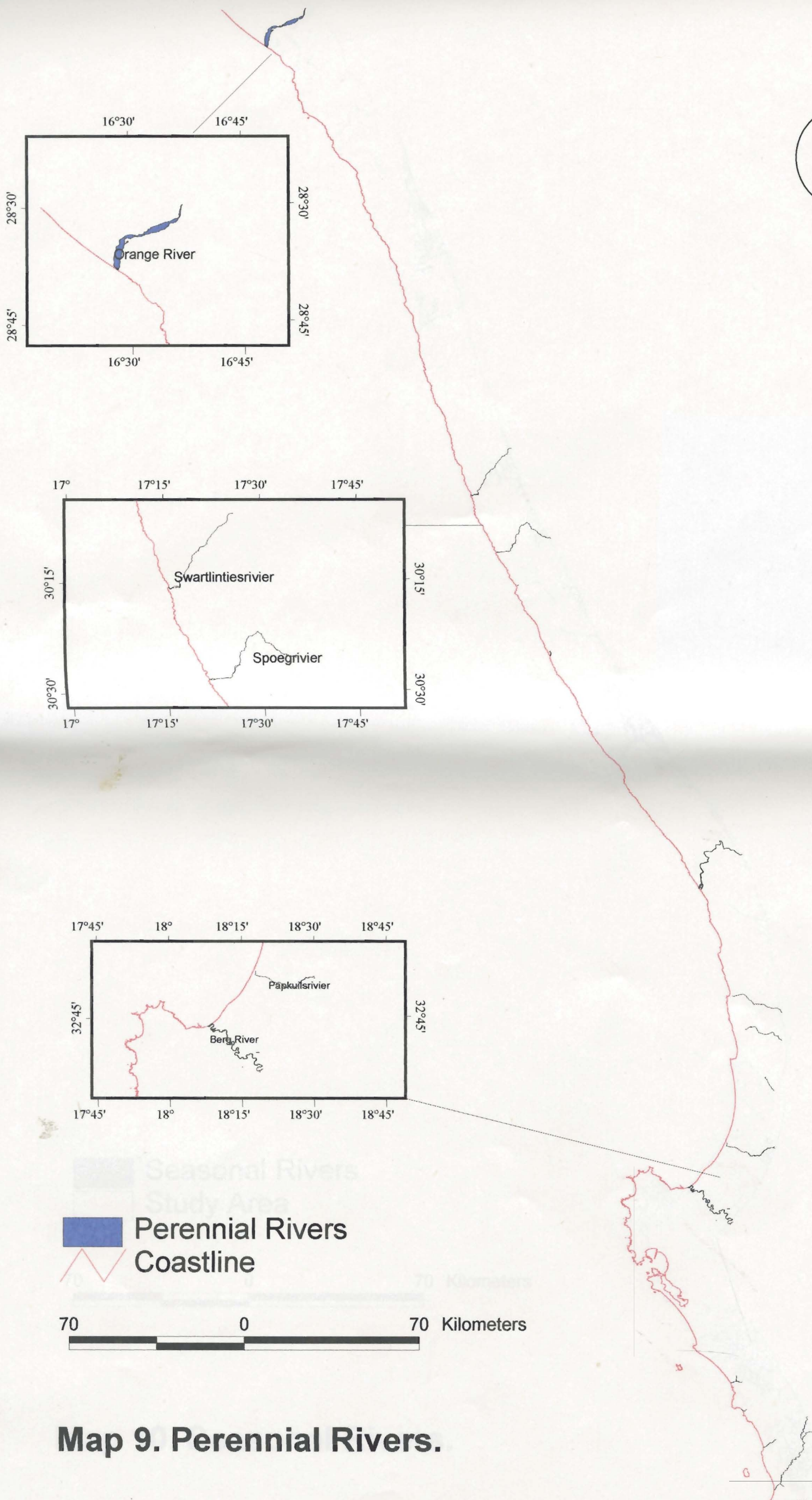


Slope Direction

-  Flat (-1)
-  North (0-22.5, 337.5-360)
-  Northeast (22.5-67.5)
-  East (67.5-112.5)
-  Southeast (112.5-157.5)
-  South (157.5-202.5)
-  Southwest (202.5-247.5)
-  West (247.5-292.5)
-  Northwest (292.5-337.5)
-  No Data

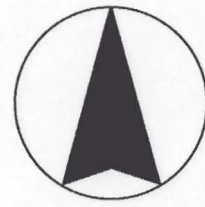
70 0 70 Kilometers

Map 8. Aspect of the Study Area.




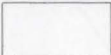
Map 9. Perennial Rivers.

17°30'



30°

32°30'

 Seasonal Rivers
 Study Area

70 0 70 Kilometers

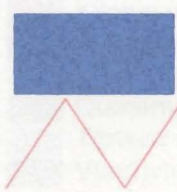
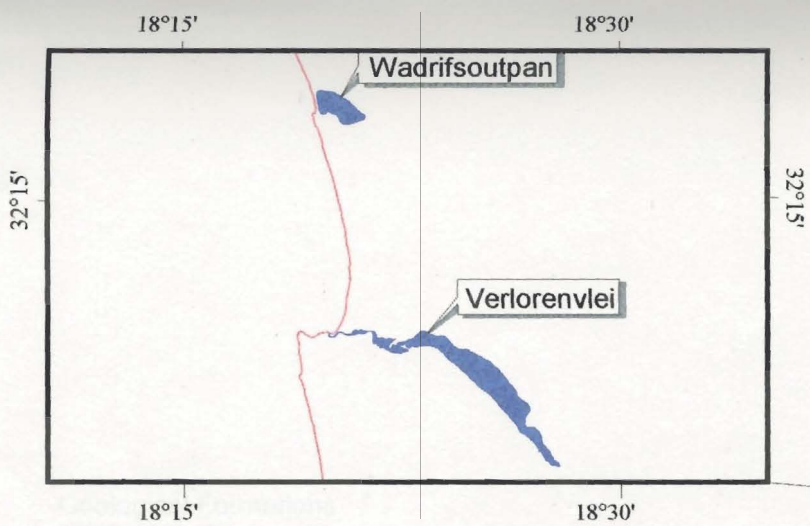
Map 10. Seasonal Rivers.



17°30'



30°



Estuaries
Coastline

70 0 70 Kilometers

32°30'

Map 11. Estuaries. Formations.

17°30'

17°30'



30°

- Geological Formations
- Cape Supergroup
 - Gariep Complex
 - Intrusive Rocks
 - Klipheuwel Formation
 - Malmesbury Group
 - Namaqualand Metamorphic Province
 - Quaternary Formations
 - Tertiary Formations
 - Vanrhynsdorp Group

70 0 70 Kilometers

A horizontal scale bar with alternating black and white segments, marked with the numbers 70, 0, and 70, representing kilometers.

32°30'

Map 12. Geological Formations.

17°30'

17°30'



30°

Vegetation Types

- COASTAL MACCHIA
- COASTAL RENOSTERBOSVELD
- MACCHIA(FYNBOS)
- NAMAQUALAND BROKEN VELD
- STRANDVELD OF WEST COAST
- SUCCULENT KAROO

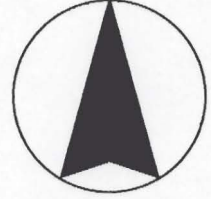
70 0 70 Kilometers

32°30'




Map 13. Vegetation Types.

17°30'

17°30'



30°

-  CRM Surveys
-  Research Surveys
-  Study Area

70 0 70 Kilometers

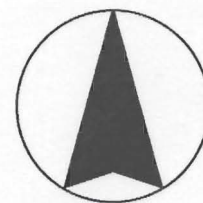
A horizontal scale bar with alternating black and white segments, marked with '70', '0', and '70 Kilometers'.

32°30'

Map 14. Research and CRM Surveys.

17°30'

17°30'



30°

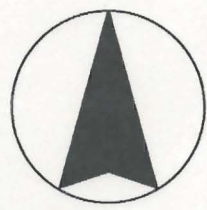


32°30'

Map 15. Sensitivity Model 1.

17°30'

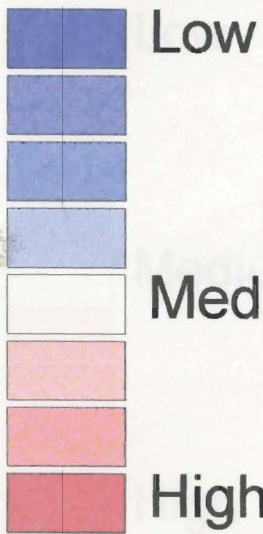
17°30'



30°

32°30'

Model1a



Map 15a. Sensitivity Model 1a.

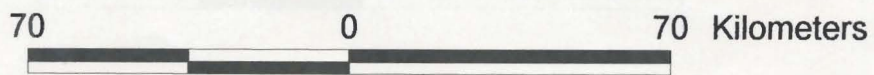
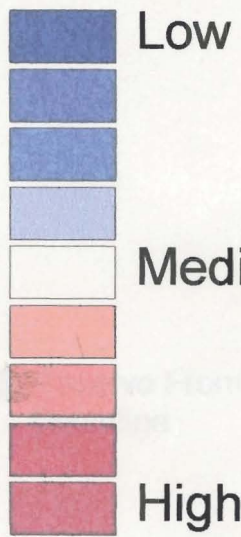
17°30'



30°

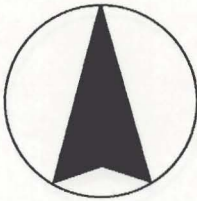
32°30'

Model2



Map 16 Sensitivity Model 2.

17°30'



30°

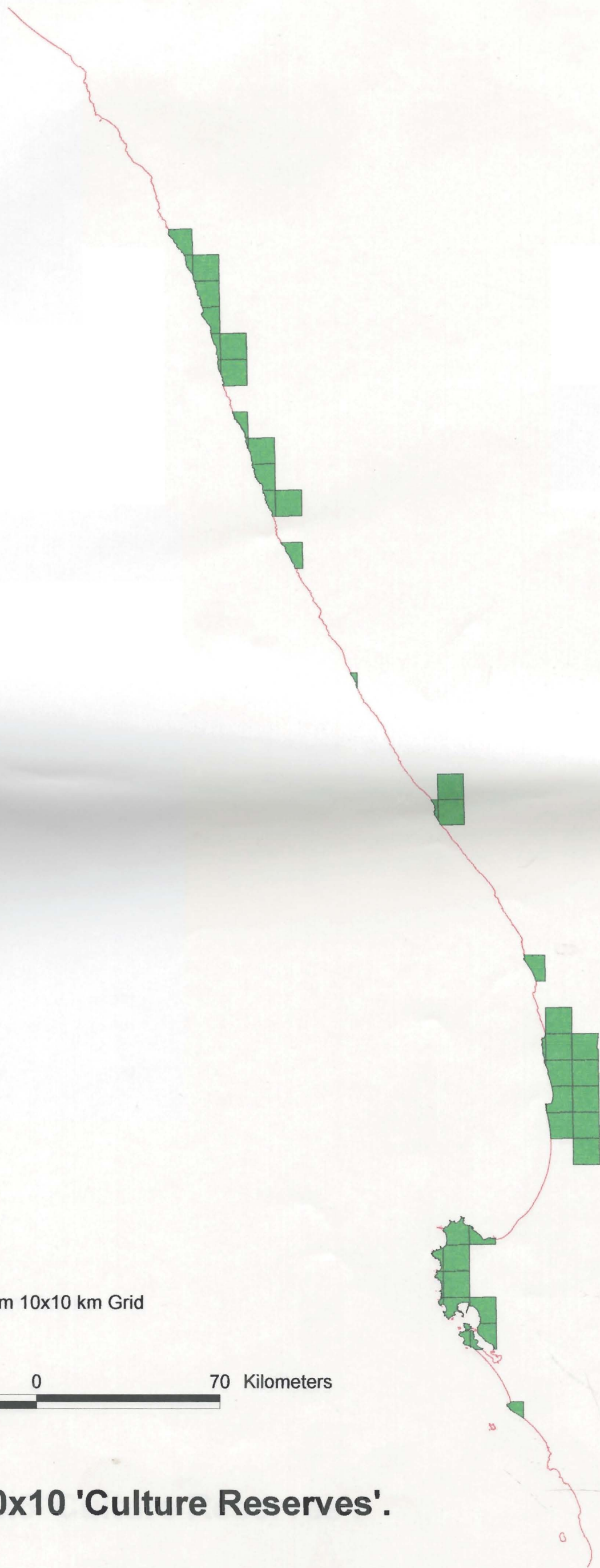
32°30'

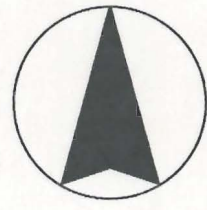
Reserve From 10x10 km Grid
Coastline

70 0 70 Kilometers

Map17. 10x10 'Culture Reserves'.

17°30'





Reserve From 5x5 km Grid
Coastline

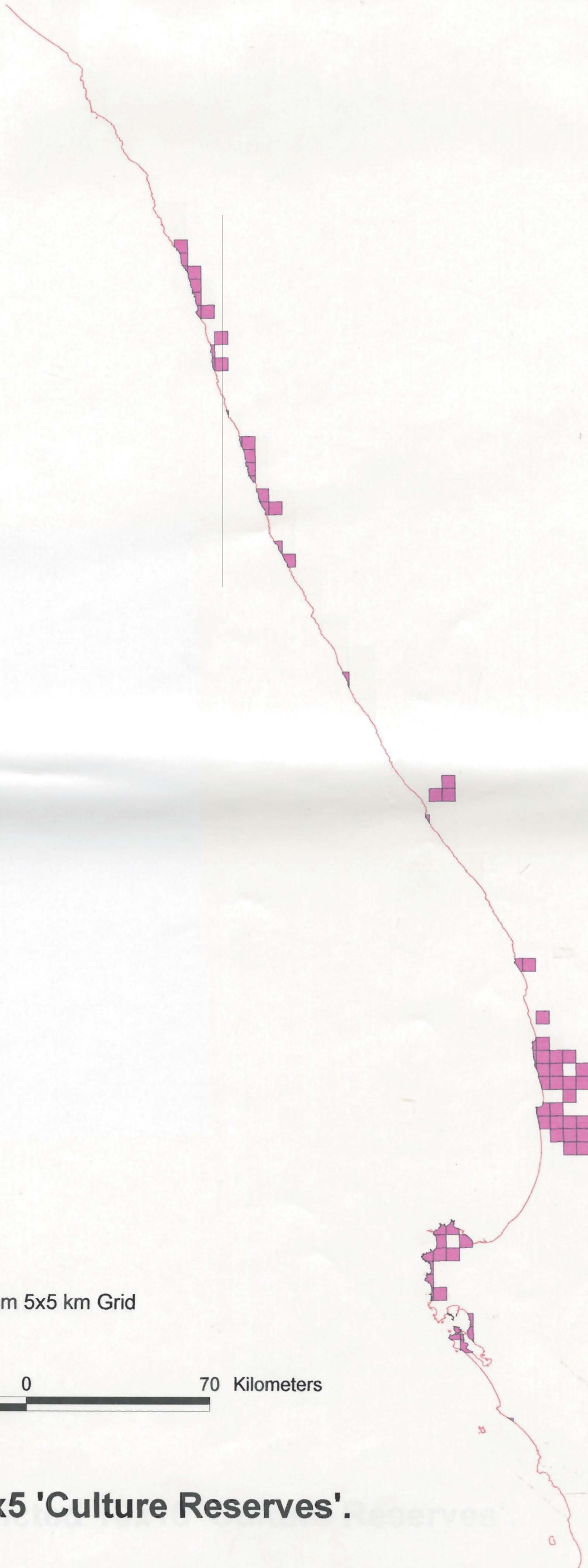
70 0 70 Kilometers

Map 18. 5x5 'Culture Reserves'.



17°30'

30°


32°30'





 Reserve From 10x10 km Grid
 Coastline

70 0 70 Kilometers

A scale bar with alternating black and white segments, marked with the numbers 70, 0, and 70.

Map 19. Predicted 10x10 'Culture Reserves'.

30°

32°30'

17°30'